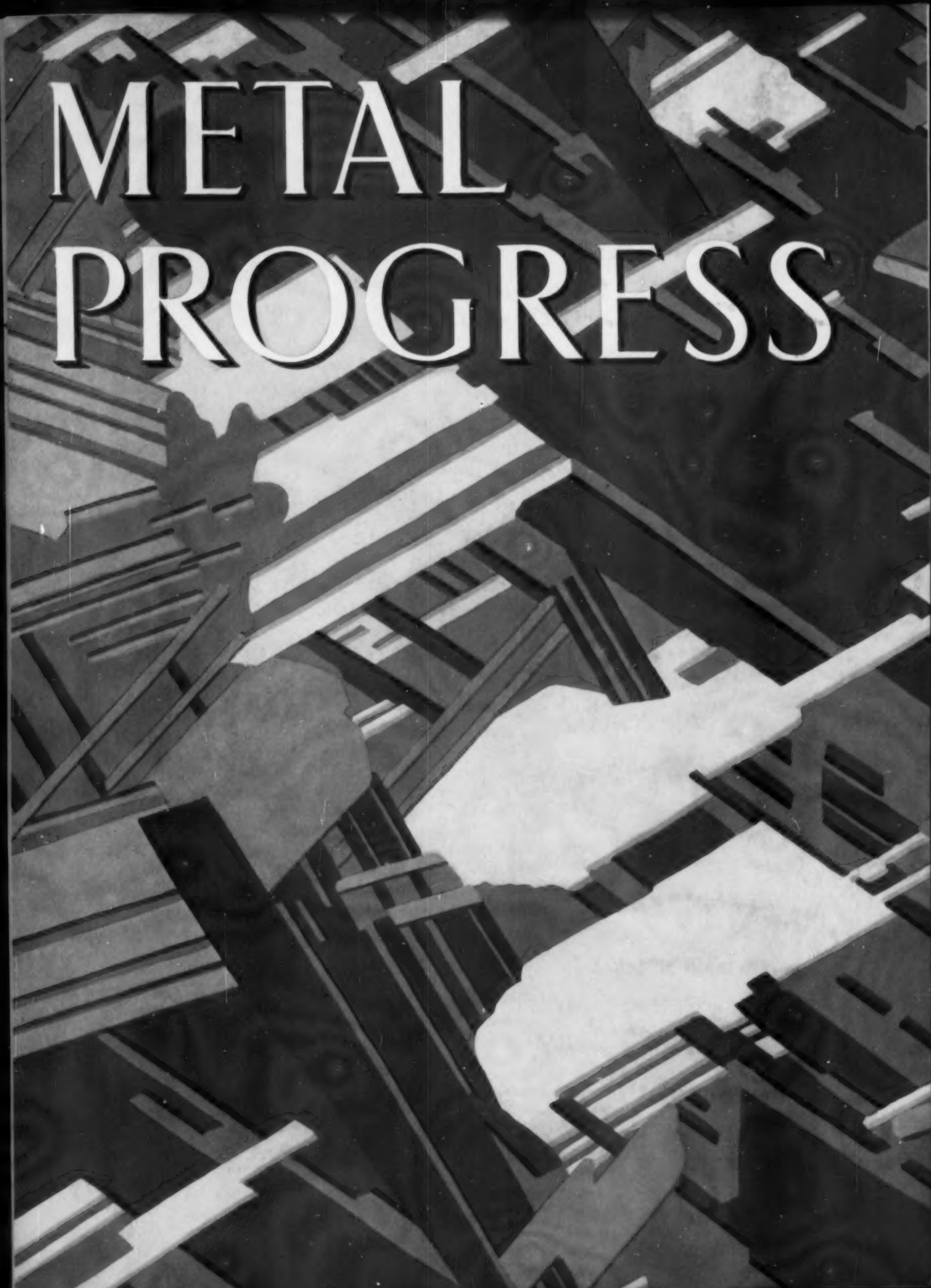

METAL
PROGRESS

Metal Progress

Volume 67, No. 6

June . . 1955

Cover is a painting by Robert F. Mehl, who is also a metallurgist and teacher of distinction, representing his view of a titanium-magnesium alloy when sufficiently magnified.

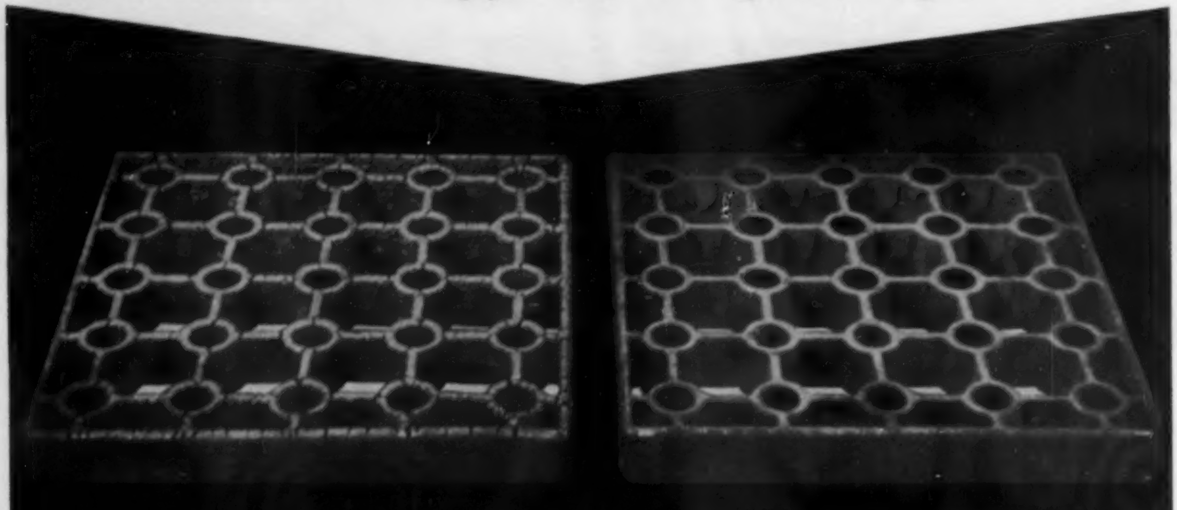
Western Metal Congress Papers (Industrial Heating Equipment Assoc.)

Engineering Articles

Table of Contents Continued on P. 3 (Volume Index Facing P. 220)

Published monthly except bi-weekly in August, by American Society for Metals. Publication office, Mt. Morris, Ill. Editorial, executive and advertising offices, 7301 Euclid Ave., Cleveland 3, Ohio. Subscription $7.50 a year in U.S. and Canada; foreign $10.50. Single copies $1.50; special issues $3.00. . . . The American Society for Metals is not responsible for statements or opinions printed in this publication. . . . Requests for change in address should include *old* address of the subscriber; missing numbers due to "change of address" cannot be replaced. Claims for nondelivery must be made within 60 days of date of issue. No claims allowed for overseas subscribers. Entered as second-class matter at the Post Office in Mt. Morris, Ill.

THERMALLOY* Application Engineering at Work



Standard trays (left) failed completely in 10 months. Thermalloy tray (right) is still in service after 33 months.

A SPLIT RUN PROVED OUR POINT!

Electro-Alloys offers engineering advantages unique in the high alloy field . . . because an experienced staff of engineers and metallurgists is available to help you design longer lasting heat-treat parts in Thermalloy.

Here's how our staff helped a large automotive manufacturer realize longer service from heat-treat trays used in carburizing service followed by oil quenching. Shown above are two types of trays used. One was of standard analysis. And the other tray was cast in a special analysis of heat-resistant Thermalloy . . . recommended by our staff after a careful study of job requirements.

We suggested that a split order of both trays be placed in identical carburizing service. The split run proved our point . . . the standard tray failed completely in 10 months, and the Thermalloy tray is still in service after 33 months.

Electro-Alloys engineering and metallurgical know-how has made a substantial difference in the life of many heat-treat and furnace parts. Can we help you? Call our nearest representative or write Elyria for Thermalloy General Catalog, T-225.

Constant research improves Thermalloy. Here, in tensile testing section, a strain indicator helps measure performance of Thermalloy up to the breaking point.

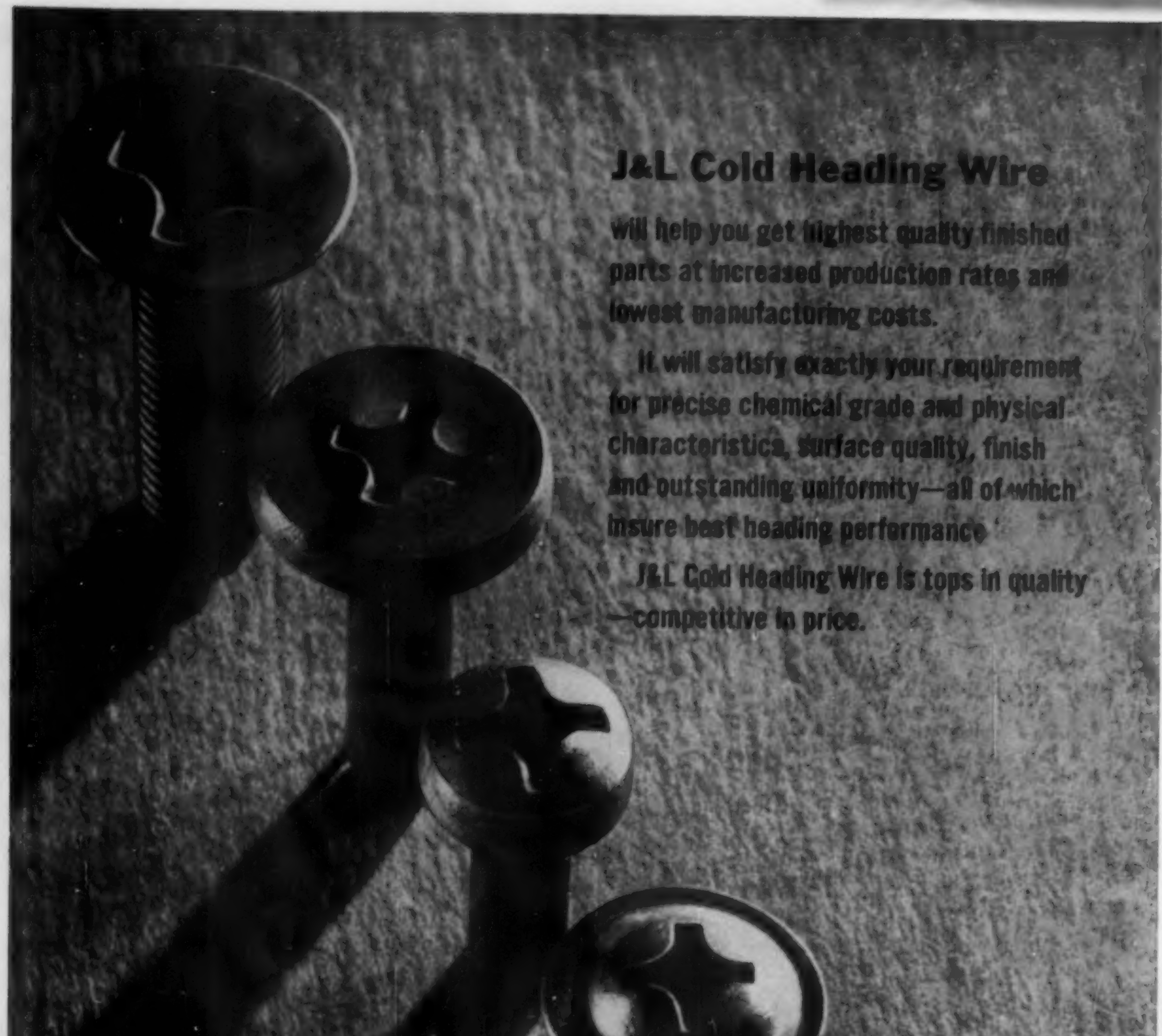
*Reg. U. S. Pat. Off.

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION

6002 TAYLOR ST., ELYRIA, OHIO

Sales offices in: Los Angeles, Oakland, Chicago, Detroit, New York, Cleveland, Philadelphia, Pittsburgh


J&L Cold Heading Wire
will help you get highest quality finished parts at increased production rates and lowest manufacturing costs.
It will satisfy exactly your requirement for precise chemical grade and physical characteristics, surface quality, finish and outstanding uniformity—all of which insure best heading performance.
J&L Cold Heading Wire is tops in quality—competitive in price.
J&L STEEL

As I was saying...

. . . and said it once before, there is no such thing as a private room in a hospital. I know because my third incarceration in an institution of that character occurred just last week when three doctors agreed that the thing to do was put me in St. Luke's and give me the works. At that point I didn't care much what they did to me, but it wasn't long until I began to take an interest. As the procession of nurses and internes wore a path to my bedroom, I challenged them to declare their identity as friend or enema. The one with the short, dull needle proved to be my friend, but at long last came the inevitable enemy, and then I had to surrender.

After three days of strenuous stomach, kidney and colon X-rays, they looked at all the charts, tests, cardiographs and metabolisms, and all joined in the unanimous chorus, "Why did they let this guy into the hospital? There is nothing wrong with him anywhere that a little liquid food and diet watching can't straighten out."

So I am enjoying six light meals a day, and I am mighty happy that those incipient ulcers decided to call it quits.

In a day or so I will be heading to Montreal from where I will embark on the Empress of Scotland to attend the Joint Metallurgical Societies Meeting in Europe. Approximately 200 will be making the trip, and they will assemble in London for the opening session June 1st. I am sure it will be a wonderful meeting, and those of us who are able to attend will consider ourselves to be very fortunate.

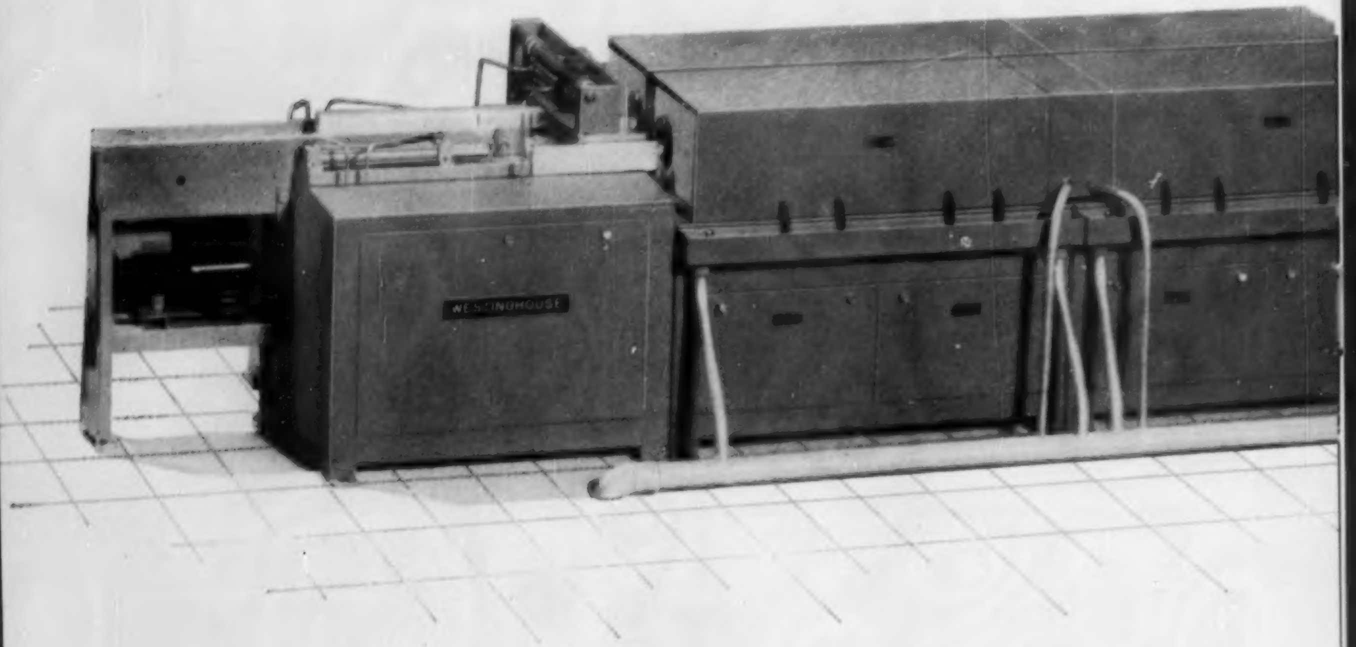
During the visits of this group to England, Germany and France, with post-convention meetings in Italy, Austria and Spain, an announcement will be made by the A.S.M. and invitations extended to all the free nations to participate in the Second World Metallurgical Congress. It will be held under the auspices of the A.S.M. Nov. 4 through 8, 1957, when the National Metal Congress and Exposition will be meeting in Chicago. You will be hearing more about it as the plans develop.

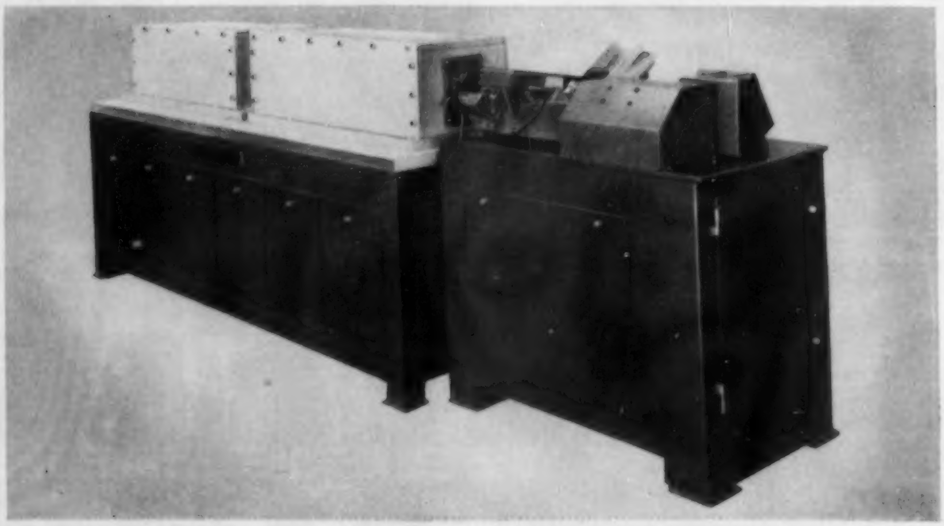
Cordially yours,

Bill

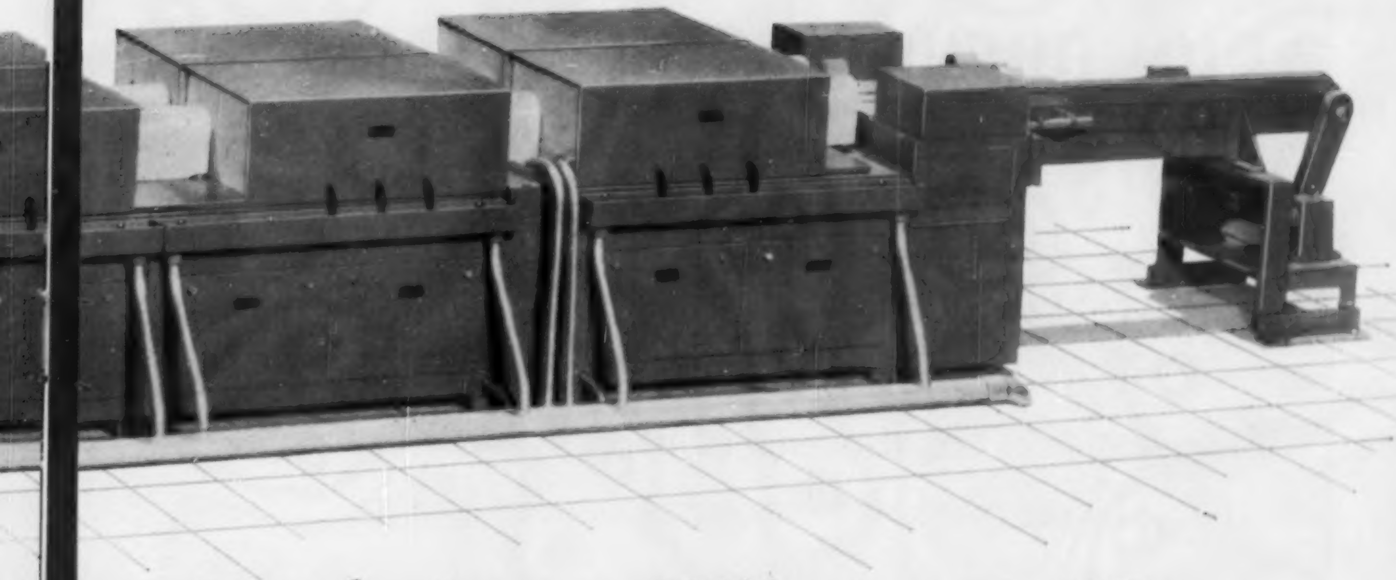
W. H. Eisenman, *Secretary*
American Society for Metals

Dual-frequency heating at its best . . . the equipment shown here (using 60 and 960-cycle power) heats 3½" R.C.S. steel billets, 8" long, to 2150° forging temperature at a rate of 480 an hour. An actual installation, using six of these machines, heats 40 tons an hour!





Another outstanding example of Westinghouse dual-frequency induction heating for forging. Clean, cool, and safe, this billet heater takes only 4' x 8' of production floor area. Using dual-frequency power (60 and 960 cycles) it heats 2½" diameter, 3¾" steel billets to 2250° forging temperature at a rate of 360 per hour.



Boost forging rate 300%, cut costs 60%...

with Westinghouse induction heating

Based on a recent forging analysis, these figures tell dramatically what savings are being accomplished by Westinghouse induction heating compared to today's "old-fashioned" methods.

How? Here are seven big savings:

- Scale loss reduced to 6/10 of a percent—60 to 80% savings.
- Longer die-life because of low scale.
- Maintenance costs cut 80%.
- Scrap loss practically eliminated.
- Flexible to all production needs—short start-up time; stand-by losses are low or nonexistent. Accurate repetitive control of temperature.
- Shearing costs eliminated.
- Pushbutton operation—completely automatic—makes it practical to put forging right in the production line.

Westinghouse ingenuity is the key. Successful installations—some with even better savings—prove that two factors are vital to full benefit of induction heating . . . good equipment and expert application.

Westinghouse offers you a complete, one source service to analyze induction heating for *your* plant. Survey, recommendation, engineering and manufacturing—all by experienced Westinghouse personnel—assure you the proper frequency, power and method of handling to most effectively reduce costs in your plant.

Right now is the time to investigate. You can lead the way to lower break-even points, decreased unit costs—point to extra profit possibilities—by bringing Westinghouse into your forging picture. Call your representative or write: Westinghouse Electric Corporation, H. F. Heating Section, 2519 Wilkens Ave., Baltimore 3, Maryland. J-02292-B

INDUCTION HEATING FOR
HARDENING • JOINING • ANNEALING
FORGING • HEAT-TREATING

YOU CAN BE SURE...IF IT'S Westinghouse

SUN QUENCHING OIL NO. 11 LASTS FOUR TIMES LONGER THAN COSTLY COMPOUNDED OIL

Provides clean bright-quenched parts at lower cost

. . . keeps tanks and coolers cleaner longer

To get clean, bright-quenched parts, J. W. Rex Company, Lansdale, Pa., one of the foremost heat treaters in the country, had to drain their 1500-gallon quench tank every few weeks. High oil cost and frequent shutdowns for tank and cooler cleaning became too expensive.

A Sun representative made a thorough analysis of this problem. He then suggested a switch to Sun Quenching Oil No. 11—at a price about half that of the costly compounded oil they were using.

Now, *twelve months later,* the original charge of Sun Oil is still in the tank! Make-up is considerably lower...parts are continuing to come out clean and bright...and... tank maintenance costs are practically nil!

To find out how a Sun Quenching Oil can help *you* heat treat metal at lower cost, phone your local Sun representative or write for Sun's latest Technical Bulletin containing complete information about Sun Quenching Oil No. 11. Address Sun Oil Company, Philadelphia 3, Pa. Dept. MP-6.

J. W. Rex, right, President of J. W. Rex Co. and Sun representative check brightness of an intricate 8620 steel part after quench in Sun Quenching Oil No. 11.

SUNOCO

INDUSTRIAL PRODUCTS DEPARTMENT

SUN OIL COMPANY

Philadelphia 3, Pa.

In Canada: Sun Oil Company Ltd., Toronto and Montreal


SUN QUENCHING OIL NO. 11
DRAINS OFF PARTS FAST

engineering digest OF NEW PRODUCTS

Brazing

Automatic brazing for many types of small and medium-size assemblies is provided by new gas-fired, packaged unit announced by Selas Corp. All equipment is mounted on an integral structural steel frame. The equipment includes a combustion controller to deliver fuel-air mixture at a prede-

termined ratio and pressure, adjustable burners, permanent or replaceable fixtures, a dial-type worktable to carry the assembly past the burners in continuous or intermittent motion, and all the necessary automatic timers, pneumatic indexing equipment and electric motors.

For further information circle No. 1495 on literature request card, page 36-B.

Alkaline Cleaner

Kelite Products, Inc., has announced a dry powder which in water solution removes hard water scale, rust and paint from ferrous metals. No electrolytic current is used and the material is nonacid. The rate of attack on copper is low, but lead, zinc and aluminum are deleteriously attacked.

For further information circle No. 1496 on literature request card, page 36-B.

Aluminum Alloy

A new aluminum alloy developed to compete with mild steel in fabrication and welding costs, has been announced by Kaiser Aluminum & Chemical Corp. It is available in "O" and H-113 temper plate ranging in gage from 0.250 to 2 in. and standard lengths in widths from 12 to 90 in. Nominal composition is 4.45% magnesium, 0.8% manganese, and 0.1% chromium.

This non-heat-treatable alloy can be welded at high speeds with inert-gas arc welds having an ultimate tensile strength of 42,500 psi. Joint efficiencies vary from 75 to 100% depending on temper of parent metal. Welds were obtained in all positions of welding. No preheating was necessary and distortion presented no problem.

Typical physical properties of 5083 plate in H-113 and "O" tempers are:

	H-113	O
Weight, lb. per cu. in.	.096	.096
Tensile strength, psi.	46,000	44,000
Compressive yield strength, psi.	33,000	22,000
Elongation, % in 2 in.	16	21

Suggested applications include such marine uses as decks, hatch covers, masts, bulkheads, superstructures and hulls. Automotive parts, structural towers for TV, railroad cars, chemical storage tanks are possibilities.

For further information circle No. 1497 on literature request card, page 36-B.

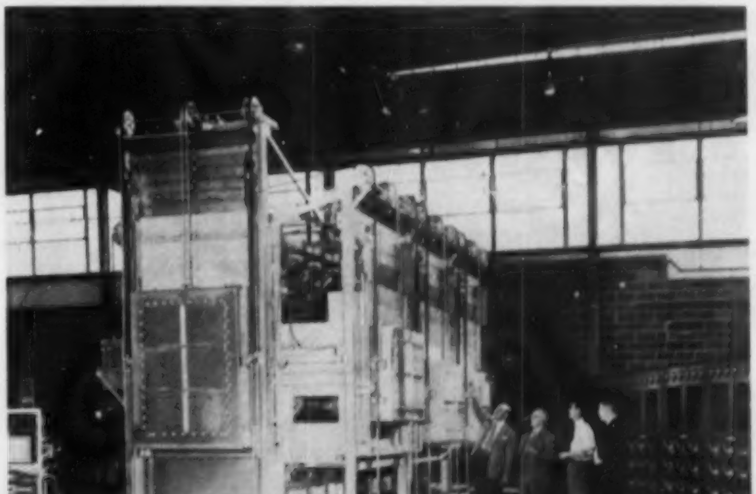
Plating Solution Filter

A new self-cleaning pressure filter for use in plating operations has been announced by the U. S. Hoffman Machinery Corp. The new filter has a stainless steel, wire-wound cylinder which supports the filter media. It does not require filter bags, sheets or

Heating Furnace

A large electric steel forging furnace which will heat billets in controlled atmosphere for a 50,000-ton forging press, has been announced by C. I. Hayes, Inc. It was installed at the Wyman Gordon Co. and built for the Air Force heavy press program. The heating chamber will accommodate 10,000 lb. of steel billets up to 16 ft. in length at one time, bringing them to a temperature of 2400° F. Overall dimensions of the furnace are 25 ft. long by 17 ft. high by 13 ft. wide. It weighs 55 tons and has a heating chamber 19 ft. long by 8½ ft. high by 4 ft. wide. It has an air-operated main loading door at front, plus three air-operated auxiliary loading doors at the side, all push-button controlled. 45 Globar heating elements are used.

For further information circle No. 1498 on literature request card, page 36-B.

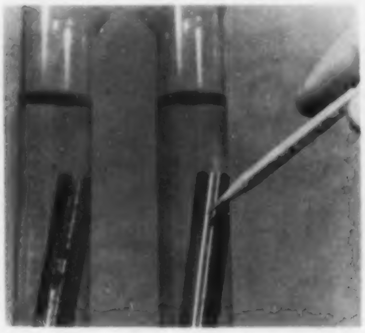


pads. A new backwashing device which accomplishes filter cleaning by turning two valves, filtration at high pressure (up to 125 psi.) without leakage, tank capacities up to 5000 gal., and a longer filtration cycle made possible by the increasing density of the filter cake are featured.

For further information circle No. 1499 on literature request card, page 36-B.

Cutting Compounds

Shell Oil Co. has announced a new entirely synthetic cutting compound which offers several advantages over conventional petroleum-base cutting fluids. The working solution prepared from this liquid has exceptional cool-



ing properties, higher speeds and feeds are thus possible, resulting in greater production rates. Dromus Oil E dissolves in water, forming a true solution instead of an emulsion. The new product may be mixed with a large volume of water to utilize the latter's very high cooling effect.

For further information circle No. 1500 on literature request card, page 36-B.

Batch-Type Ovens

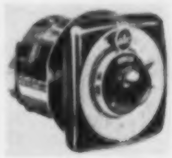
A standard line of batch ovens, available with either gas or electric heat source, has been announced by Grieve-Hendry Co. These ovens are adaptable for burn-off in preparation

for painting and finishing. Other uses include baking all new types of finishes, preheating, drying, curing, dehydrating and all types of baking operations. Air circulation is automatic, both horizontal and vertical, completely surrounding the work to assure uniform temperature. Gas models have Eclipse gas burners with electric push-button ignition and safety pilot. Electric models have Inconel-sheathed heating elements with outside terminals and are equipped with high and low heat switch. Other features include indicating temperature controller, combustion safety system and gas controls.

For further information circle No. 1501 on literature request card, page 36-B.

Timer

An automatic reset timer with dial setting for timing and sequencing of electrical load circuits on industrial machinery and process operations has been announced by Automatic Temperature Control Co. Applications listed by manufacturer are vacuum metallizing, bonderizing, photography, honing, lapping, grinding and die casting.



Timer mounts into single round cutout 3 3/16 in. in diameter and is secured in place by tension studs on back-up ring held in position by O-ring retainer. It can be installed into panels up to ⅛ in. thick.

For further information circle No. 1502 on literature request card, page 36-B.

Refractory

A new silicon carbide refractory capable of withstanding temperatures under load up to 3000° F. has been announced by Electro Refractories & Abrasives Corp. The refractory slabs are used in kilns for firing porcelainware. Slab sizes used in field tests ranged from 8 x 10 x ⅛ in. thick to 16 x 18 x ¾ in. thick. In other applications, sizes as heavy as 23 x 25 x 3 in. thick have been successful. Both the plain silicon carbide and sandwich-type slabs of silicon carbide surfaced with chemically inert refractories have been produced.

For further information circle No. 1503 on literature request card, page 36-B.

Magnesium Alloy Sheet

Brooks & Perkins, Inc., have announced magnesium-thorium alloy HK31 sheet and plate with 3% thorium and 1% zirconium. The thorium alloys of magnesium were formerly available only as castings. These alloys have high tensile strength and creep resistant properties at 300 to 700° F. They are particularly useful for jet engine and missile applications, where they fill a gap in light weight

materials available for use in this temperature range.

For further information circle No. 1504 on literature request card, page 36-B.

Dipping Baskets

The Chas. Wm. Doepke Mfg. Co. has announced a new line of perforated stainless steel baskets of all-welded, die-made construction for metal cleaning. Available in five different sizes

ranging from 12 to 36 in. in length, the units can be supplied in various types of stainless steel as well as in aluminum or cold rolled steel. A variety of perforation sizes is offered.

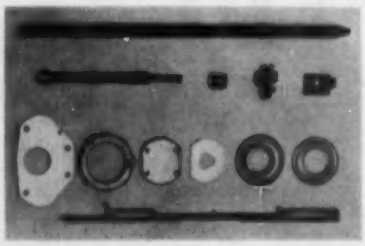
For further information circle No. 1505 on literature request card, page 36-B.

Correction

On page 13 of the April issue, the Charpy impact value of Wearpact steel was given incorrectly. The correct value is 20 ft.-lb. Castings of this alloy steel are made by American Steel Foundries.

Dry Cyaniding

Standard Steel Treating Co. has announced the availability of the dry-cyaniding process. The advantages of the process are illustrated by the automotive oil pump cover. If the part



is carburized to a depth of 0.050 in., 0.020 to 0.030 in. has to be ground off each side to make the parts flat. Grinding reduces the wear resistance because much of the carbon-rich part of the case has been removed. If the part is dry-cyanided, the stamping is finish ground and then treated. The part is then ready for use. Advantages claimed are stock size can be reduced, amount of grinding is reduced, heat treating is simpler and less expensive and the finished part has greater wear resistance.

For further information circle No. 1506 on literature request card, page 36-B.

High-Vacuum Pump

A new, completely dry, high-vacuum pump has been announced by Consolidated Vacuum Corp. It combines a titanium evaporation process and ion pumping to produce low pressures (less than 10^{8} mm. Hg) without using refrigerated traps or baffles. It was developed to produce a vapor-free vacuum for the large high-voltage particle accelerators used in atom-smashing. Other potential applications include the evacuation of electron power tubes, color TV tubes, large X-ray tubes and mass spectrometers.

For further information circle No. 1507 on literature request card, page 36-B.

Spectrochemical Source Unit

Recent improvements in their Multisource unit have been announced by Applied Research Laboratories. High and low voltage circuits and d-c. arc elements are each packaged and wired separately, providing a new unity of construction. The resulting flexibility enables the Multi-

source to perform either as a special purpose source or as a general purpose research instrument, through addition or subtraction of components. A patented principle for obtaining identical powers in each spark gives the unit reproducible voltage range of 850 to 20,000 volts. Solids, liquids and powders, with elements in wide ranges of concentration, can be analyzed.

For further information circle No. 1508 on literature request card, page 36-B.

pH Meter

Photovolt Corp. has announced a large-size indicating meter of 7 in. scale length which covers the pH range from 0 to 14 without switching


USS
Quality
FORGINGS
heavy machinery parts—carbon, alloy, stainless
forged steel rolls and back-up roll sleeves
electrical and water wheel shafts
hammer bases and columns


. . . now in operation!

These typical properties show why Crucible 430 stainless was a good choice for the *Murray* worm drive clamp.

Tensile Strength — a. Room Temperature — 75,000 psi. b. At 1700F — 3500 psi

Yield Strength — 40,000 psi

Elongation — 30%

Hardness — 160 BHN

Endurance Limit — 40,000 psi

Creep Strength — Stress for 1% elongation in 10,000 hours at 1300F-1300 psi

Resistance to Scaling — Suitable for continuous service to 1600F.

the finest products wear a STAINLESS *label...*

When you label a product *stainless steel* it means lasting dependability . . . good looks . . . and resistance to wear or corrosion.

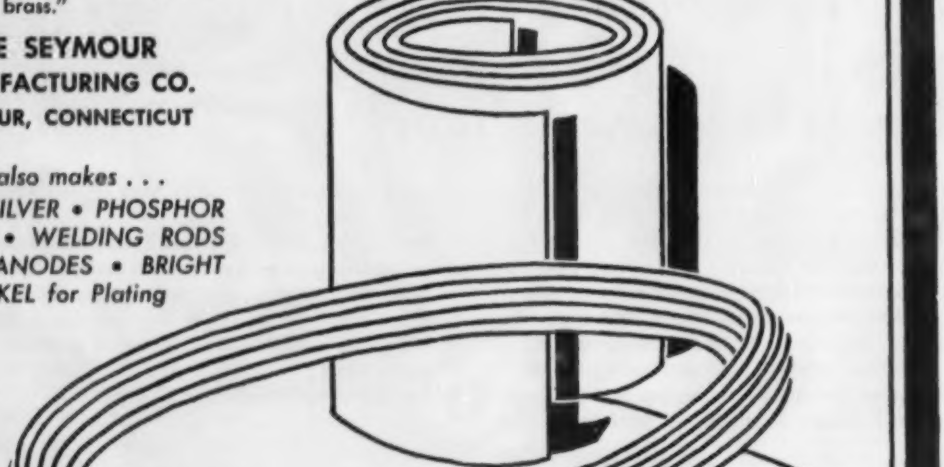
That's why the Murray Corporation, Towson, Maryland, chose Crucible stainless for the worm drive hose clamps shown above. These clamps need the high strength, wear and corrosion resistance that only *stainless steel* can provide.

Stainless has other advantages, too. Its high creep and fatigue strength . . . heat resistance . . . and excellent workability may be just what you're looking for.

At Crucible stainless steels are *prescription-made* by steelmen with over a half century of experience in *special purpose* steelmaking. They'll welcome the opportunity to help you make the most profitable use of stainless for your products. *Crucible Steel Company of America, Henry W. Oliver Building, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America



and without reversal of the pointer travel. The instrument can be furnished in a portable shape with baseboard and carrying cover. The available accessories include a swing-arm adapter for immersing the electrodes by tilting motion and a shielding hood for use of unshielded electrodes.
For further information circle No. 1509 on literature request card, page 36-B.

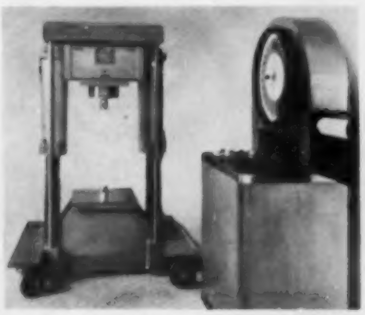
Portable Oven

The Carl Mayer Corp. has announced a new portable industrial oven for use in production and laboratory work. These cabinet ovens are avail-

able with either horizontal or vertical air flow. They employ a high pressure motor driven blower to propel the heated air in a definite air-flow pattern through the work chamber. Other features of the ovens include no metal-to-metal contact, high and low heat switch for close control and quick recovery, electrical interlock for turn-off of heat in case of blower motor failure and Inconel-sheathed heating elements.
For further information circle No. 1510 on literature request card, page 36-B.

Testing Machine

A portable hydraulic testing machine of 60,000 lb. capacity in tension and compression has been announced by Baldwin-Lima-Hamilton Corp. The



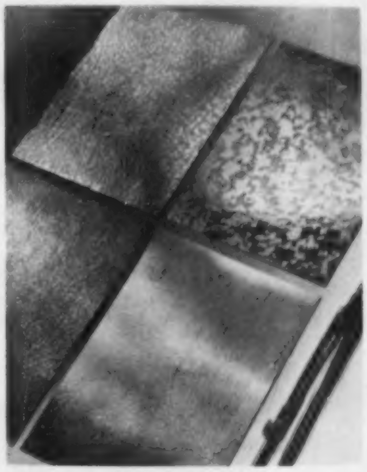
new testing machine is able to apply both tension and compression in a common testing space over a fixed table 24 in. above the floor. A double-acting hydraulic capsule is used in the weighing system which is separate and independent of the hydraulic loading system. A standard null-balance indicator on the control console has three ranges—0 to 60,000, 0 to 12,000 and 0 to 2400 lb. The testing machine can be operated as far as 25 ft. from a stationary control console but both units may be mounted on casters.
For further information circle No. 1511 on literature request card, page 36-B.

Cemented Carbide

A new sintered carbide material for cutting, heavy roughing and finishing of steel at increased rates of productivity on both high and low-speed machines has been announced by Kennametal, Inc. K21 has a Rockwell hardness of A-91.5 and high transverse rupture strength.
For further information circle No. 1512 on literature request card, page 36-B.

Embossed Strip

A new pattern designed strip steel has been announced by Pittsburgh Steel Co.'s Thomas Strip Div. The patterns are rolled into cold rolled strip steel in almost any design that can be drawn on a piece of paper. The



strip can be supplied in plain uncoated steel or electrolytically coated with copper, brass, nickel, chromium, zinc or lead alloy. It can be hot dip coated with lead alloy or tin, and lacquer coated. Strip is being produced in widths up to 18 in. and in a range of thicknesses from 0.010 to 0.125 in. depending on the pattern, the type of coating and the finish required.
For further information circle No. 1513 on literature request card, page 36-B.

Low-Temperature Chamber

Tenney Engineering, Inc., has announced the first self-contained table-model low-temperature test chamber. Measuring only 29⅛ x 57 x 30½ in. and weighing but 450 lb., this model produces temperatures to —100° F. and will dissipate 1000 Btu. per hour

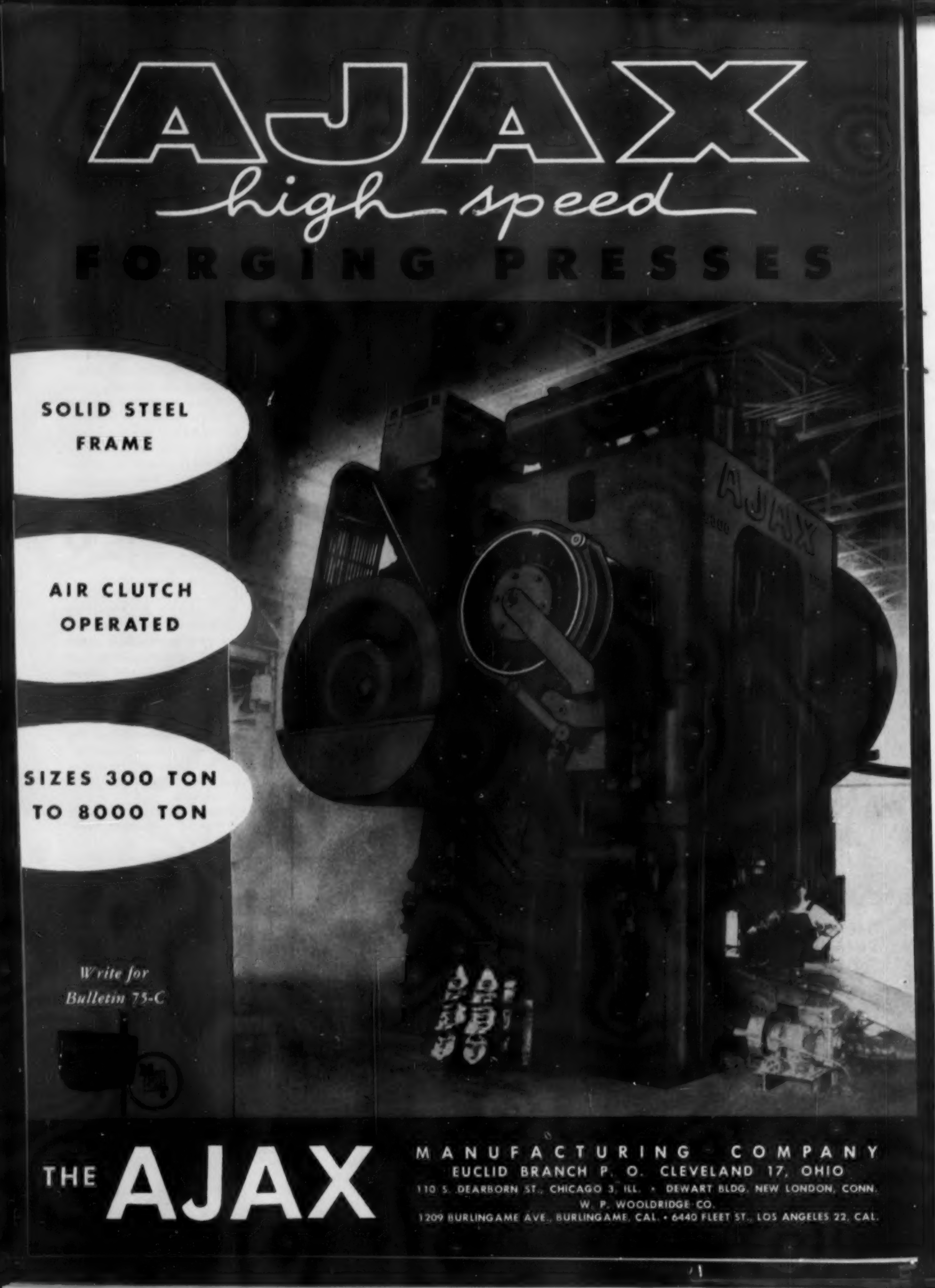
at —80° F. It also produces high temperatures to 212° F. The cascade system of refrigeration is used. This system actually embodies two interlinked refrigeration circuits, the evaporator of one being the cooling element of the condenser of the second. The refrigeration tubing encircles the 1 x 1 ft. work space instead of being arranged in a bank along one side as is customary. Heating is accomplished by nonglowing, low surface-temperature heaters located in the rear of the chamber.
For further information circle No. 1514 on literature request card, page 36-B.

Crucibles

Electro Refractories & Abrasives Corp. has announced large carbon-bonded silicon carbide crucibles made to handle as much as 1100 lb. of molten aluminum. They are almost three times the size of the customary pots, which hold only up to 400 lb. of aluminum. These crucibles are manufactured by an improvement on the age-old pottery technique of spinning. This imparts a laminated structure that increases the strength and flexibility of the crucibles.
For further information circle No. 1515 on literature request card, page 36-B.

Heat Treating Fixtures

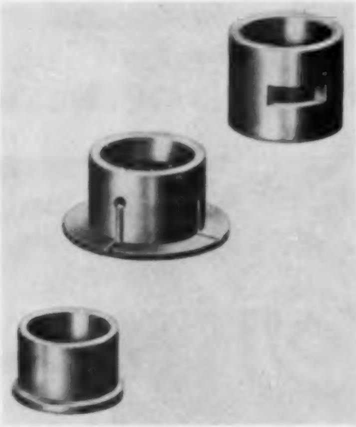
Cambridge Wire Cloth Co. has announced the development of a new design for fixtures for annealing, carburizing, carbonitriding and other bulk heat treating operations. Nonbinding joints employ tubular rivets and loosely-fitting spacer sleeves to


AJAX
high speed
FORGING PRESSES
SOLID STEEL FRAME
AIR CLUTCH OPERATED
SIZES 300 TON TO 8000 TON
Write for Bulletin 75-C
THE AJAX MANUFACTURING COMPANY
EUCLID BRANCH P. O. CLEVELAND 17, OHIO
110 S. DEARBORN ST., CHICAGO 3, ILL. • DEWART BLDG. NEW LONDON, CONN.
W. P. WOOLDRIDGE CO.
1209 BURLINGAME AVE., BURLINGAME, CAL. • 6440 FLEET ST., LOS ANGELES 22, CAL.

replace the welded, soldered and other fixed joints formerly used in heat treating trays. Specific allowances for thermal expansion and contraction provide free movement of all joints during heating and cooling. The new design decreases the basket-load weight ratio.
For further information circle No. 1516 on literature request card, page 36-B.

Bearing Alloy

Bunting Brass & Bronze Co. has announced a new, silvery white bearing metal alloy developed for bearing installations in modern food processing machines. It combines satisfactory anti-friction bearing qualities, high resistance to corrosion and good ap-



pearance. The chemical composition of Bunting No. 183 is 63 to 67% copper, 3½ to 4½% tin, 3 to 5% lead, 6 to 10% zinc and 19½ to 21½% nickel. It has a tensile strength of 30,000 psi., yield strength of 17,000 psi., elongation 8% in 2 in. and Brinell hardness of 95.
For further information circle No. 1517 on literature request card, page 36-B.

Cutting Fluid

Carbide and Carbon Chemicals Co. has announced a synthetic, water-soluble cutting fluid for increasing tool life 300 to 500% in machining titanium. The fluid forms a clear solution with all proportions of water and this permits visibility of work being cut, formed or ground. Uncon H-660 can also be used on carbon, alloy and stainless steels and nonferrous alloys.
For further information circle No. 1518 on literature request card, page 36-B.

Measuring Machine Speeds

Development of a Celerimeter for the measurement of very high machinery speeds has been announced by Lake Erie Engineering Corp. It will give the straight-line speed of moving sections of fixed machinery and equipment. The Celerimeter is portable and

capable of measuring speeds ranging from 5 to 30,000 in. per min. The synchronous-motor indicator measures 1/100 sec. intervals. The complete unit weighs 26½ lb. and is supplied in a case measuring 9 x 9 x 21 in. It operates on 110 volts, 60 cycles.
For further information circle No. 1519 on literature request card, page 36-B.

Optical Pyrometer

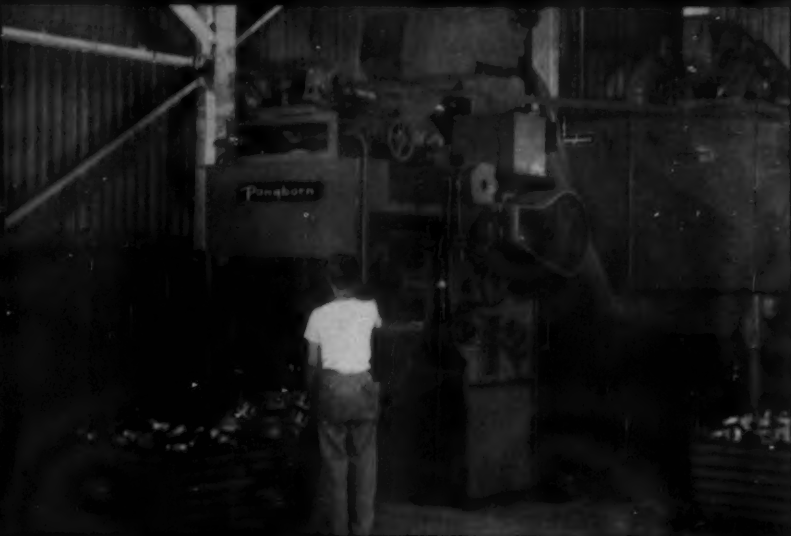
Light in weight and easy to use, the Mason Instrument Co. has announced an optical pyrometer for the 1000 to 2500° F. range. It is fully portable and requires no connection of any kind. One pyrometer can monitor the temperature of any number of kilns or furnaces. The 9-in. long scale is easily read to within 10° F. in a matter of

seconds by a simple brightness match, and a built-in calibrating meter assures accuracy. The eyepiece can be focused.
For further information circle No. 1520 on literature request card, page 36-B.

Spectrophotometer

A new infrared recording spectrophotometer for either quantitative or qualitative analysis has been announced by Baird Assoc. Design of the unit provides 1 min. interchange of prisms. Use of four prisms—sodium chloride, calcium fluoride, lithium fluoride and potassium bromide—gives this model a spectral range of 1.5 to

Looking for cheaper blast cleaning?



PANGBORN BLAST CLEANS CHEAPER BECAUSE famous Pangborn Rotoblast cleans *fast.* Rotoblast throws a heavy volume of abrasive quickly over a large surface area. This speed of operation increases your rate of production, cuts operating expenses.

◄ BLASTMASTER Barrel for batch cleaning

Pangborn . . .

Pangborn . . .

PANGBORN BLAST CLEANS CHEAPER BECAUSE Rotoblast actually does a terrific job! Its uniform cleaning action economically produces a more desirable, brighter finish and allows more efficient use of high-speed machine tools in further processing.

ROTOBLAST ROOM for miscellaneous work ►

Pangborn . . .

PANGBORN BLAST CLEANS CHEAPER BECAUSE Rotoblast saves labor costs . . . because it requires less power to operate . . . because its versatility accommodates a wide range of work. Send for Bulletin 227 today. Write PANGBORN CORPORATION, 1800 Pangborn Blvd., Hagerstown, Md. *Manufacturers of Blast Cleaning and Dust Control Equipment.*

◄ ROTOBLAST "GO" Barrel for continuous-flow requirements

Whatever Pangborn Rotoblast machine best suits *your* requirements . . .

Pangborn
BLAST CLEANS CHEAPER

Rotoblast Blastmaster® & Continuous-Flo Barrel | Rotoblast Tables & Table-Rooms | Special Blast Rooms & Cabinets | Pangborn Dust Control Equipment | Malleabrasive® Shot & Grit

26 microns. It is claimed that the spectrophotometer will produce up to 100 complete spectra in a 24 hr. period.
For further information circle No. 1521 on literature request card, page 36-B.

Filter

A new 800 gal. per hr. capacity filter with a new stainless steel-cloth bag element or porous stone has been announced by Bart - Messing Corp. The filter element is fastened to the hand tightened cover, and can be lifted out manually for quick and thorough washing. The portable filter requires only 50 in. of head room and measures 32 in. in diameter at the base. All working parts are suspended underneath the tank to protect them from dirt and drippings. Units are constructed of extra-low-carbon stainless steel and are furnished complete with operating valves, motor and pump.

For further information circle No. 1522 on literature request card, page 36-B.

Induction Heater

A low-frequency induction heater, which will handle magnesium billets or rectangular slabs up to 32 in. in largest section by 71 in. long, has been announced by Magnethermic Corp. The heater will preheat magnesium

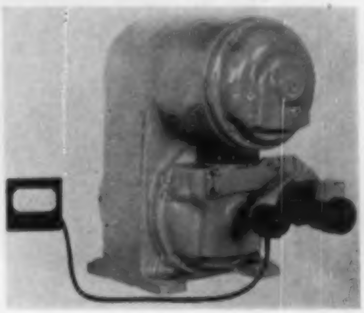
billets for a 13,000-ton horizontal extrusion press. The unit is rated at 2000 kw., operates on 4160 volts, 3 phase, 60 cycles and will heat up to 10 tons of magnesium an hour.
For further information circle No. 1523 on literature request card, page 36-B.

Stripper

Enthone, Inc., has announced a powder that speeds the action of acids for dissolving defective chromium and nickel from copper-base metals without injuring the base metals. It has been used successfully by manufacturers of radio and electronic equipment, household appliances, cameras, office and business machinery and automobile parts. This dry powder is added to certain acids to increase the rate of dissolving on nickel and chromium thousands fold.
For further information circle No. 1524 on literature request card, page 36-B.

Speed Indicator

Sterling Electric Motors, Inc., has announced that the Speed-Trol variable speed drive can now be equipped with a direct pick-up electric Tachometer. The device includes a signal generator and speed indicator. Standard calibration of the indicator is in



revolutions per minute and it can also be furnished calibrated in various units of production such as feet per minute, gallons per hour, cubic feet per minute. Speed-Trols are available in ratings from ½ to 30 hp. in standard, single, double or triple reduction drives.
For further information circle No. 1525 on literature request card, page 36-B.

Indicator

A new precision indicator has been announced by the General Electric Co.'s Instrument Department. It is designed to scan a number of process variables by the use of a manual switching arrangement on the front panel. The precision indicator may be used with provision for measuring up to 48 different circuits, or in conjunction with a multi-point strip-chart recorder to obtain an intermittent record. The instrument incorporates a magnetic standard to provide continuous measurement and standardization. It is available in two basic types, d.c. potentiometer or a.c. bridge, and it can be provided as a single-point or multiple-point instrument.

For further information circle No. 1526 on literature request card, page 36-B.

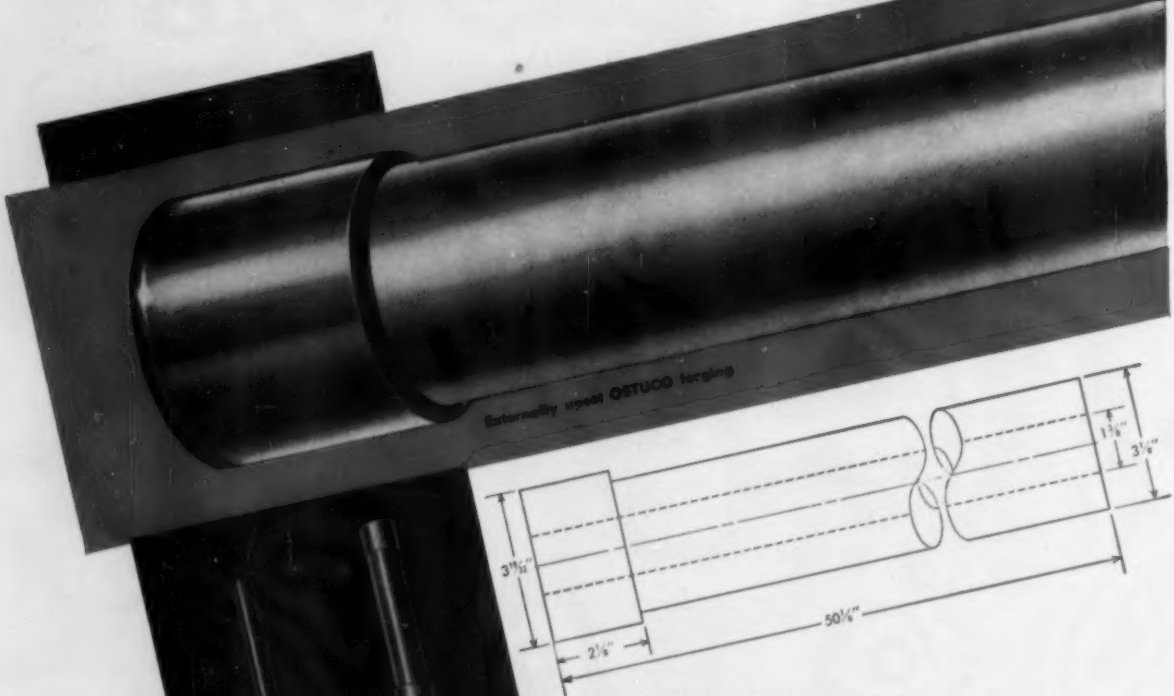
WHAT'S NEW

pressed carbides, cutting tools, drawing dies, wear resistant parts. *Metal Carbides*

Externally Upset OSTUCO Tubing

saves 31% on processing improves mandrel life

for Halliburton Oil Well Cementing Company



A savings of 31% over previous manufacturing methods, was made possible by using externally upset OSTUCO Tubing as Wall Packer Mandrels in "Howco" Expanding Shoe Assemblies. These OSTUCO forgings eliminated a welding operation and reduced machining time and cost. One-piece fabrication greatly improved the useful life of the part.

Compare your tubing costs with job-designed OSTUCO Tubing. *Special-quality* OSTUCO Tubing is manufactured to your individual requirements . . . formed to save processing time and waste. Fill all your tubing requirements on *one* order with OSTUCO'S unique *single-source* service. You'll eliminate interplant shipment, reduce error and speed delivery. Wire, write or phone OSTUCO for complete details, or submit blueprints for immediate quotation.

OSTUCO TUBING

SEAMLESS AND ELECTRIC WELDED STEEL TUBING
—Fabricating and Forging

OHIO SEAMLESS TUBE DIVISION
of Copperweld Steel Company • **SHELBY, OHIO**
Birthplace of the Seamless Steel Tube Industry in America
SALES OFFICES: BIRMINGHAM • CHARLOTTE • CHICAGO (Oak Park) • CLEVELAND • DAYTON • DENVER • DETROIT (Ferndale) • HOUSTON • LOS ANGELES (Beverly Hills) LOUISVILLE • MOLINE • NEW YORK • NORTH KANSAS CITY PHILADELPHIA • PITTSBURGH • RICHMOND • ROCHESTER ST. LOUIS • ST. PAUL • SEATTLE • TULSA • WICHITA
CANADA, RAILWAY & POWER ENGR. CORP., LTD.
EXPORT: COPPERWELD STEEL INTERNATIONAL COMPANY
117 Liberty Street, New York 6, New York

WHAT'S NEW

IN MANUFACTURERS' LITERATURE

1536. Alloy Castings
Data folders on two types of alloy steel castings. Composition, properties, hardenability bands, uses. *Unitcast*

1537. Alloy Steel
32-page book on abrasion resisting steel. Properties, fabricating characteristics, uses. *U. S. Steel*

1538. Alloy Steel
Data book on the selection of the proper alloy steel grades for each manufacturer's needs. *Wheelock, Lovejoy*

1539. Alloy Steel
16-page book on type 9115 low-alloy high-strength steel. Properties, fabrication, welding. *Great Lakes Steel*

1540. Alloy Steel
40-page book on applications of heat treated, special alloy steel. *Jones & Laughlin*

1541. Aluminum
12-page booklet on extruded shapes, tube and pipe, coiled sheet, forgings and properties of aluminum alloys. *Revere*

1542. Aluminum Cleaning
48-page booklet gives practical tips on materials and methods of cleaning aluminum and magnesium. *Oakite*

1543. Aluminum Finish
Bulletin on new invisible finish for aluminum describes Alodine No. 1000 and includes flow sheet for immersion process. *American Chemical Paint*

1544. Aluminum Forgings
12-page booklet on press forgings, impact extrusions and hand forgings. Properties of aluminum forging alloys. *Harvey Aluminum*

1545. Ammonia Atmospheres
12-page bulletin B-52 on dissociated ammonia furnace atmospheres. *Drever*

1546. Ammonia Dissociators
Bulletin on dissociating process gives advantages of ammonia as controlled atmosphere. *Sargeant & Wilbur*

1547. Atmosphere Furnace
Bulletin on controlled atmosphere furnace. *Industrial Heating Equipment*

1548. Atmosphere Furnace
Information on mechanized batch-type atmosphere furnaces for gas cyaniding, gas carburizing, clean hardening or carbon restoration. *Dow Furnace*

1549. Atmosphere Generator
Bulletin on laboratory size dissociated ammonia generator. *Boder Scientific*

1550. Atmospheres
8-page Bulletin SC-155 discusses following controlled atmospheres: RX, DX, NX, HNX, AX, HX. Compositions, applications, effects on steel, drawings of generators. *Surface Combustion*

1551. Barrel Finishing
32-page handbook on compounds for descaling, deburring, coloring, metal cleaning and rust inhibition. *Lord Chem.*

1552. Basic Materials
24-page booklet on Alundum, Crystolon, Magnorite, Norbide, zirconia, carbide, borides and other basic materials. Products made from them are listed. *Norton*

1553. Bearing Puller
Folder on tool for extracting ball and roller bearings. *Engineering Imports*

1554. Be-Cu, Wrought
"Applications Unlimited", collection of case histories on successful uses of wrought beryllium copper. *Beryllium*

1555. Beryllium Copper
Bulletin 1 on available alloys, conditions, tempers and tables of sizes and properties. *Penn Precision Products*

1556. Bimetal Applications
36-page booklet, "Successful Applications of Thermostatic Bimetal", describes 22 uses. *W. M. Chace*

1557. Black Oxide Coatings
8-page booklet on black oxide coatings for steel, stainless steel and copper alloys. *Du-Lite*

1558. Blackening Compounds
Bulletin on blackening compounds for ferrous alloys to AMS Spec 2485. *Swift Industrial Chemical*

1559. Boiler Refractories
New 20-page bulletin on boiler refractories discusses basic requirements of refractories, what causes refractories to fail, kinds of insulating firebrick. *Refractories Div., Babcock & Wilcox*

1560. Brass
New 20-page pocket-size booklet on brass rod mill products. Weight tables, specifications. *Titan Metal Mfg.*

1561. Brass Tubing
Bulletin on seamless, brazed and lock-seam tubing in brass and copper. *H & H Tube and Mfg.*

1562. Brazing
Folder on low-temperature brazing tells how to boost brazing production. *Handy & Harman*

1563. Brazing
Bulletin 124—on salt bath brazing process—shows how it is possible to substitute brass for copper and develop joints of adequate strength for most steel assemblies. *Ajax Electric*

1564. Brazing Titanium
Data sheet on use of a new flux for brazing titanium. *Handy & Harman*

1565. Bronze
Folder gives tables of properties, uses, forms and other data on phosphor bronzes. *Chase Brass & Copper Co.*

1566. Buffing Compounds
Bulletin B-7 lists various compounds and gives applications. *Apothecaries Hall*

1567. Bulb Thermometers
44-page catalog covers selection data, recorders and indicators, controls, psychrometers, bulbs, tubing and fittings. *Minneapolis-Honeywell*

1568. Burners
8-page reprint No. 43 on Method for Improving Temperature Uniformity in Furnaces. *North American Mfg.*

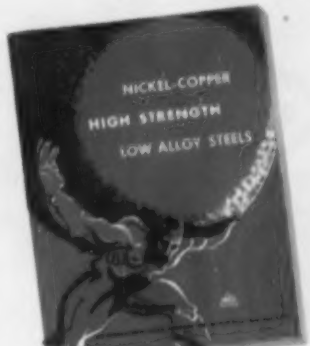
1569. Carbides
84-page catalog of sintered carbides, hot pressed carbides, cutting tools, drawing dies, wear resistant parts. *Metal Carbides*

1570. Carbon Control
Technical report on instrument for control of carbon potential of furnace atmospheres. *Lindberg Eng'g*

1571. Carbonitriding
Literature on Ni-Carb (carbonitriding) treatment for surface hardening. *American Gas Furnace*

1535. High Strength Steels

This 48-page booklet is a discussion of the nickel-copper, high strength, low alloy steels sold under various trade names, such as Cor-Ten, Mayari-R, Yoloy and others. Compositions range fom 0.40 to 2.00% nickel and from 0.25 to 1.30% copper. Other alloying elements used are



manganese, silicon, phosphorus, sulphur and in some types small amounts of chromium and molybdenum. Tensile strength is 70,000 psi. min., yield point, 50,000 psi., min., and elongation in 2 in. is 22%. Cold forming, hot forming, machining, punching, shearing and welding are discussed. A large section of the booklet deals with the corrosion resistance of the copper-nickel steels. Advantages of these steels are cited. Applications in railroad cars, trucks, busses, ships, mining and construction equipment, bridges, agricultural equipment and others are discussed and illustrated.—*International Nickel Co.*

1572. Carburizing
Data folder on Aerocarb E and W water-soluble compounds for liquid carburizing. Case depth vs. time curves. Per cent carbon and nitrogen penetration curves. *American Cyanamid*

1573. Cemented Carbides
16-page bulletin gives mechanical and physical properties of carbides for tools and high-temperatures. *Kennametal*

1574. Centrifugal Castings

1593. Cut-Off Wheels

1574. Centrifugal Castings
Booklet on spun centrifugal castings of bronze for liners, rings, rolls, sleeves, bushings. *American Non-Gran Bronze*

1575. Charging
12-page brochure on eight models of charging machines for heating and melting furnaces. *Salem-Brosius*

1576. Chromate Finishing
File on chromate conversion coatings for prevention of corrosion and paint-base treatment of nonferrous metals. *Allied Research Products*

1577. Cleaners
Bulletins on di-phase cleaners, specifications, equipment, advantages. *Solventol*

1578. Cleaning
Data on chemical for removing scale, rust and paint from ferrous alloys. *Kelite*

1579. Cleaning Aluminum
12-page bulletin on cleaning process for preparing aluminum and magnesium for welding. *Northwest Chemical*

1580. Coatings
New folder on adhesives, coatings and sealers for joint-sealing, bonding and protecting sheet metal. *Minnesota Mining and Mfg. Co.*

1581. Continuous Cast Bronze
12-page bulletin on properties and uses of continuous cast bronze rod and tube. *American Smelting & Refining*

1582. Controller
New 12-page bulletin 5A-13 on pneumatic indicating controller for control of process variables. *Foxboro*

1583. Controllers
Bulletin 1060 on millivoltmeter controllers gives specifications and models. *Minneapolis-Honeywell*

1584. Controllers
16-page educational bulletin No. 9 gives data, operation diagrams, schematic drawings of capacitrols. *Wheelco Instruments*

1585. Controllers
Data sheets on indicating pyrometric controllers, proportioning controllers, portable controllers, pyrometer accessories. *West Instrument*

1586. Controls
Bulletin 2101 on application of Honeywell temperature controls, limit controls, valves and combustion safeguards to Maxon Premix industrial gas burners. *Minneapolis-Honeywell*

1587. Copper Alloys
New 48-page book contains tables of alloys with composition, typical uses, general, working, mechanical, electrical properties, hardness, ASTM specification numbers. *Revere*

1588. Copper Alloys
40-page book on eleven copper alloys. Properties, cleaning, annealing. *Seymour*

1589. Corrosion Data
Data Card 160 gives comparative resistance to various corrosive media of several stainless steels. *Babcock & Wilcox*

1590. Corrosion Resistance
20-page bulletin on copper alloys for corrosion resistance. Table gives applicability in 150 media. *Ampco*

1591. Creep Testing
6-page bulletin diagrams and describes dynamic creep testing machine. *Ivy Co.*

1592. Creep Testing
Data on operation and instrumentation of Arcweld lever arm creep testing machine. *Minneapolis-Honeywell*

1593. Cut-Off Wheels
Folder gives data, operating suggestions and grade recommendations of cut-off wheels. *Manhattan Rubber Div.*

1594. Cutting Oil
Facts on more efficient and economical plant operation through use of right lubricants described in "Metal Cutting Fluids" booklet. *Cities Service*

1595. Cutting Tools
36-page booklet analyzes and compares carbon, high speed, cast alloy and carbide tool materials. *Allegheny Ludlum*

1596. Degreaser
40-page book on properties and use of trichlorethylene. Methods of handling and safety measures. *Niagara Alkali*

1597. Degreasing
New bulletin 953-1 on vapor degreasing, and advantages. Equipment. *Ramco Equipment*

1598. Degreasing
34-page booklet on vapor degreasing. Design, installation, operation and maintenance of equipment. *Circo Equipment*

1599. Demineralizer
New 20-page catalog on demineralizers which heat up to 2500 gal. per hr. Dimensional and performance data. *Barnstead Still & Sterilizer*

1600. Descaling Stainless Steel
Bulletin 25 on descaling stainless steel and other metals in molten salt. *Hooker Electrochemical*

1601. Design of Dies
32-page bulletin on design of dies for upset forging. Also rules for upsetting and examples of forgings. *Ajax Mfg.*

1602. Die Casting
Bulletin on high-pressure hydraulic die casting machine. Convertible from hot metal to cold chamber machine. *Cleveland Automatic Machine Co.*

1603. Die Casting
Booklet on "High-Speed Precision Die Casting Machines". *Reed-Prentice*

1604. Die Castings
Set of five design standards for tolerances on die castings of zinc, aluminum, magnesium and copper. *American Die Casting Institute*

1605. Die Steel
Bulletins on air-hardening, high-carbon, high-chromium die steel containing sulphide additives. *Latrobe*

1606. Dryers
24-page bulletin No. 222 shows installations of air drying equipment in various industries. *Pittsburgh Lectrodryer*

1607. Electric Furnaces
New bulletin on electric heat treating furnaces gives summary of progress in furnace developments. *Holcroft*

1608. Electric Furnaces
Brochure on electric heat treating, melting, metallurgical tube, research and sintering furnaces. *Pereny Equipment*

1609. Electric Melting
Bulletin 537 on compact arc furnace. Melt time and power consumption for four alloys. *Detroit Electric Furnace*

1610. Electron Microscope
New 20-page booklet on special features and uses of electron microscope. *RCA*

1611. Embossed Stainless
Folder on cost advantages, end use advantages and extra dividends. *Rigidized Metals*

1612. Extrusion Presses
8-page bulletin on aluminum extrusion

presses describes the process and presses at work. *Watson-Stillman*

1613. Fabrication
Booklet on welded steel heavy fabrication pictures and describes how various products are made. *R. C. Mahon*

1614. Fans
20-page catalog on forward curve and backward blade ventilating fans. *General Blower Co.*

1615. Fasteners
New bulletin on die-cast zinc alloy wing nuts and screws, cap nuts, rivets, round head thumb nuts and thumb screws. *Gries Reproducer*

1616. Ferro-Alloys
32-page book tells how ferro-alloys are made and how they are used. *Electro Metallurgical Co.*

1617. Filters
Bulletin on application of industrial filters to oil quenching process. Experience with two applications. *Industrial Filtration Co.*

1618. Finishing
Two 8-page bulletins on dip tank and flow coat finishing describe processes, advantages and disadvantages of two processes. *Du Pont Finishes Div.*

1619. Finishing
Six bulletins describing finishing compounds for stainless steel, aluminum, other metals. *Apothecaries Hall*

1620. Finishing
Bulletin 531 on silicone-base heat-resistant finish. *Midland Ind. Finishes*

1621. Flame Hardening
New 20-page catalog on flamatic hardening machines and allied equipment. *Cincinnati Milling Machine Co.*

1622. Flow Meters
Bulletin 201 on flow meter for gas used in heat treating. *Waukee Eng'g*

1623. Forging Hammer
New 20-page catalog on design features and uses of electro-pneumatic hammer. *Lobdell United Division*

1624. Forging Hammers
24-page brochure describes construction and use of steam drop hammers. *Erie Foundry*

1625. Forgings
Folder on large forgings of carbon and alloy steel. *Struthers Wells Corp., Titusville Forge Div.*

1626. Forgings
94-page book on die blocks and heavy-duty forgings. 20 pages of tables. *A. Finkl & Sons*

1627. Foundry Coatings
Data on colloidal graphite for mold washes, pattern coatings, core coatings, chill coatings. *Acheson Colloids*

1628. Furnace Controls
22-page booklet on instruments and controls for heat treating furnaces. *Hays Corp.*

1629. Furnace Fixtures
16-page catalog on baskets, trays, fixtures and carburizing boxes for heat treating. 66 designs. *Stanwood Corp.*

1630. Furnace Maintenance
16-page "Maintenance Guide for Electric Heat Treating Furnaces" on preventive program. *Hevi Duty Electric*

1631. Furnaces
Folder describes complete set up for heat treatment of small tools, including draw furnace quench tank and high temperature furnace. *Waltz Furnace*

1632. Furnaces
40-page book describes gas and electric furnaces and applications. Four basic types of atmospheres. Glossary of heat treating terms. *Westinghouse*

1633. Furnaces
Data on electric furnaces of top or side loading types. *Lucifer Furnaces*

1634. Furnaces
Bulletin on specially designed continuous production furnaces for brazing, sintering, bright annealing, heat treating, bar heating, melting, forging. *Harper Electric Furnace Corp.*

1635. Furnaces
44-page Catalog 112 features furnaces for hardening, tempering, carbonitriding, forge heating, sintering, annealing and tool heat treating. Also atmosphere generators and ammonia dissociators. *C. I. Hayes*

1636. Furnaces
16-page Bulletin 135 on industrial furnaces and atmosphere generators. Continuous systems. *Continental Industrial Engineers*

1637. Furnaces
Catalog on furnaces for tool room and general purpose heat treat. *Cooley*

1638. Furnaces
Folder on new sizes, specifications for soft metal reverberatory furnaces. *Eclipse Fuel Engineering*

1639. Furnaces, Heat Treating
32-page catalog on high-speed gas furnaces for heat treating carbon and alloy steels; also pot furnaces for salt and lead hardening. *Charles A. Hones*

1640. Furnaces, Heat Treating
12-page bulletin on conveyor furnace, radiant tube gas heated, oil or electrically heated. *Electric Furnace Co.*

1641. Fused Silica
Folder on fused silica which is resistant to high temperatures, thermal shock, acids and has high electrical insulating value. *Amersil*

1642. Gages
Data sheets on vacuum gages, direct reading, continuous measurement, control circuits. *Consolidated Vacuum*

1643. Gamma Radiography
12-page booklet on setting up and operating a gamma radiography installation. *Technical Operations*

1644. Gamma Radiography
8-page catalog on gamma-ray radiography with radioactive cobalt 60 and iridium 192. *Mitchell Radiation Products*

1645. Gas Generator
Bulletin G-16A on gas-fired and electric endothermic generators. Specifications. *Ipsen Industries*

1646. Globar Furnaces
Bulletin 153 describes nine types of furnace using silicon carbide heating elements for temperatures to 2600° F. *Hevi Duty*

1647. Gold Plating
Folder on salts for bright gold plating. Equipment needed. *Sel-Rex*

1648. Graphite
6-page revised bulletin No. 435 on colloidal graphite for surface coatings and impregnation. *Acheson Colloids*

1649. Graphite
New 20-page brochure on significance of graphite as electrodes, anodes, molds and specialties in electrometallurgy and electrochemistry. *Great Lakes Carbon*

1650. Graphite Molds
Data on two types of molds for casting

magnesium, steel, copper, brass and other metals. *National Carbon*

1651. Graphitic Tool Steels
48-page booklet on heat treating data, properties and 46 specific applications of graphitic tool steel. *Timken*

1652. Grinding Magnesium
Data on how to grind and polish magnesium alloys includes grinding wheel recommendations, procedures, dust collection and safety precautions. *Norton*

1653. Handling Devices
Pamphlets on clamps for lifting and handling. Their application to various industries. *Merrill Bros.*

1654. Hard Surfacing
40-page hard facing manual tells what metals can be hard faced, how to select right hard facing material, lists step-by-step procedures and industrial applications. *Haynes Stellite*

1655. Hardness Tester
20-page book on hardness testing by Rockwell method. *Clark Instrument*

1656. Hardness Tester
Bulletin on hardness tester for all regular and superficial Rockwell tests. *Kent Cliff Div., Torsion Balance Co.*

1657. Hardness Tester
Literature on Brinell testing machines. *Detroit Testing Machine Co.*

1658. Hardness Testers
20-page bulletin on models, applications and how to use superficial hardness testers. *Wilson Mechanical Instrument*

1659. Heat Treating
Loose leaf data sheets on heat treating oils, salts, carburizing compounds. *Park Chemical*

1660. Heat Treating
8-page bulletin on continuous heat treating. Flow diagrams, equipment. *Surface Combustion*

1661. Heat Treating
New 20-page catalog on the Homocarb method with Microcarb atmosphere control for heat treatment of steel. *Leeds & Northrup*

1662. Heat Treating Baskets
12-page bulletin on wire mesh baskets for heat treating and plating. *Wiretex*

1663. Heat Treating Belts
Catalog of conveyor belts and data for their design, application and selection. *Ashworth Bros.*

1664. Heat Treating Equipment
4-page folder on 17 different types of industrial heat treating equipment. *Ferguson Equipment Corp.*

1665. Heat Treating Fixtures
24-page catalog on heat and corrosion-resistant equipment for heat treating and chemical processing. 30 classifications of equipment. *Pressed Steel*

1666. Heat Treating Guide
Chart guide constructed on slide rule principle for simplified hardening and drawing of tool steels. *Carpenter Steel*

1667. Heat Treating Pots
Bulletin 110 gives data on sizes and shapes of cast nickel-chromium solution pots. *Fahralloy*

1668. Heaters
New folder on uses and various forms of fused quartz radiant heaters. *Cleveland Process Co.*

1669. Heating Elements
24-page Bulletin H on electric heating elements. Includes extensive tabular data on physical and electrical specifications for various sizes. *Globar Div.*

1670. High Alloy Castings
New 16-page bulletin, No. 3354-G, gives engineering data concerning castings used for resisting high temperatures, corrosion and abrasion. *Duraloy Co.*

1671. High-Speed Steels
New bulletin on free machining tool steels and die steels. Descriptions, composition, heat treatment. *Vanadium-Alloys Steel*

1672. High-Speed Tools
Folder on forged high-speed steel tools. *Nelco Tool Co.*

1673. High-Temperature Belts
New bulletin on belts of high-temperature alloy for heat treat furnaces. *Electro-Alloys Div.*

1674. High-Temperature Belts
24-page bulletin on metal conveyor belts. *Wickwire Spencer*

1675. High-Temperature Steels
87-page book on factors affecting high-temperature properties. 45 pages of data on tensile, creep and rupture properties of 21 high-temperature steels. *U. S. Steel.*

1676. Hydrogen Atmosphere
Bulletin on equipment for supplying hydrogen with oxygen content less than one part per million and dew point to −70° F. *Baker & Co.*

1677. Impact Testing
Bulletin on machine for Izod, Charpy and tension testing. *Riehle*

1678. Induction Heating
New 12-page bulletin on low-frequency (60-cycle) induction heating furnace for nonferrous metals. *Magnethermic*

1679. Induction Heating
12-page bulletin B-6519 on motor generator sets, r.f. generators, work stations, handling equipment. *Westinghouse Electric*

1680. Induction Heating
60-page catalog tells of reduced cost and increased speed of production on hardening, brazing, annealing, forging or melting jobs. *Ohio Crankshaft*

1681. Induction Heating
36-page bulletin on high-frequency induction heating unit for brazing, hardening, soldering, annealing, melting and bombarding. *Lepel*

1682. Induction Heating
12-page Bulletin 13-A on high frequency induction furnace for forging, upsetting, spinning, annealing, hardening. *Ajax Electrothermic*

1683. Induction Heating Control
New Bulletin HT-1 on automatic temperature control for induction heating equipment. Types of control, components of induction heaters. *Minneapolis-Honeywell*

1684. Industrial Fans
Catalogs on various kinds of industrial fans — exhaust, multiblade, backward curve, for high temperatures. *Garden City Fan*

1685. Insulation
40-page industrial products catalog on insulations, refractory products, and others. *Johns-Manville*

1686. Interference Microscope
Bulletin B-602 describes new Zeiss instrument for fast nondestructive examination and photography for wave-length measuring of surface finishes in the order of one millionth of an inch down to 300 Angstroms. *Boder Scientific Co.*

1687. Joining
Folder on Koldwelding tool and how it may be used for lap and butt welds. *Utica Drop Forge*

1688. Joining Stainless
24-page booklet on various welding methods, soldering, brazing, flame cutting and arc cutting of stainless. *Crucible Steel*

1689. Laboratory Supplies
Instruments and apparatus for control, research, development laboratories. *Harshaw Scientific*

1690. Leaded Steels
Folder on lead-bearing, cold finished bars which machine about 80% faster than B1113. *LaSalle Steel*

1691. Light Metal Heating
New booklet on ovens for heat processing of aluminum, magnesium and titanium. *Michigan Oven*

1692. Lubricant
Literature on anti-seize molybdenum disulfide lubricant. *Bel-Ray*

1693. Machining Copper
32-page booklet gives cutting speeds, feeds, rakes, clearances for more than 40 copper alloys. *American Brass*

1694. Machining Copper
12-page bulletin on machining properties, practices, feeds, speeds, tool design. *Ampco*

1695. Machining Steels
Guide to selection of fastest machining steels. *Ryerson*

1696. Magnesium
8-page folder on facilities for working of magnesium and titanium. *Brooks & Perkins*

1697. Magnesium Applications
60-page book gives 54 case studies on uses. *Dow Chemical*

1698. Malleable Iron
12-page Bulletin 5797 on electric-furnace annealing of malleable iron. *General Electric*

1699. Mechanical Cleaning
12-page catalog of wheel brushes gives design, specifications, speeds at which they may be used. *Fuller Brush Co.*

1700. Melting Aluminum
Bulletin 310 on furnaces for melting aluminum. *Lindberg Eng'g*

1701. Melting Furnaces
28-page catalog on Heroult electric melting furnaces. Types, sizes, capacities, ratings. *American Bridge*

1702. Metallurgical Products
Chart of typical chemical analysis and commercial uses of zirconium oxides, silicates, soluble salts, metallurgical and foundry alloys. *Titanium Alloy Mfg.*

1703. Microhardness Tester
Bulletin describes the Kentron microhardness tester. *Torsion Balance Co.*

1704. Micropolishing
10-page brochure on units for polishing coils, blanks and sheets. *Murray-Way*

1705. Microscopes
Catalog on metallograph and several models of microscopes. *United Scientific*

1706. Microscopes
8-page booklet No. 5 on research microscopes, stages, illuminators and other accessories. *American Optical*

1707. Microscopes
22-page catalog describes microscopes featuring ball bearings and rollers throughout the focusing system and a low-position fine adjustment, providing comfortable operation. *Bausch & Lomb*

1708. Mill Equipment
Profusely illustrated journal featuring facilities available for production of rolling mills, steel castings and steel rolls. *Continental Foundry & Machine Co.*

1709. Monel
New booklet on engineering properties of cast Monel. *International Nickel Co.*

1710. Nickel Alloy
32-page booklet, Equipping the Pickle House, on use of Monel, its corrosion resistance, strength and ductility. *International Nickel*

1711. Nickel Alloys
Wall chart gives engineering properties of nickel alloy wire, rod and strip. Includes Monel, Inconel, Incoloy and nickel-clad copper. *Alloy Metal Wire Co.*

1712. Nickel Chromium Steels
8-page bulletin with 28 charts on composition, heat treatment, transformation characteristics and mechanical properties of the standard nickel-chromium steels. *International Nickel*

1713. Nickel Plating
Booklet on bright nickel plating process. *United Chromium*

1714. Nondestructive Testing
8-page bulletin on equipment for nondestructive testing of bars, rods, tubing. *Magnetic Analysis*

1715. Oil Filter
8-page folder 201 on multi-cartridge oil filters describes complete line. *Houdaille-Hershey*

1716. Oil Quenching
8-page brochure tells in detail how carbon steel often can replace alloy steel when additive is used in the quenching oil. *Aldridge Industrial Oils*

1717. Ovens
16-page bulletin No. 53 on various types of core and mold ovens, special ovens and heat treating furnaces. *Carl Mayer*

1718. Ovens
New Bulletin 10-S on cabinet ovens describes those for use with gas, electric and steam heat for temperatures to 600° F. *Young Brothers*

1719. Phosphate Coating
12-page "Phosphate Coating Chemicals and Processes" gives data on paint bonding, rust proofing, protecting friction surfaces, improving drawing and extrusion. *American Chemical Paint*

1720. Pickling Baskets
12-page bulletin on mechanical picklers, crates, baskets, chain and accessories. *Youngstown Welding & Eng'g*

1721. Pickling Baskets
Data on baskets for degreasing, pickling, anodizing and plating. *Jelliff*

1722. Pipe and Tubing
68-page book on pipe and tube making, answering many pertinent questions on tube mill operation and production. Engineering data and specifications. *Yoder*

1723. Plate Fabrication
New 12-page bulletin on experience and facilities for steel and alloy plate fabrication. *Downingtown Iron Works*

1724. Polishing Materials
20-page booklet includes samples of emery, aluminum oxide and silicon carbide papers and 12 polishing cloths. *Buehler Ltd.*

1725. Powder Metallurgy
New literature on advantages in powder

(*Continued on p. 36-A*)

(Continued from p. 35)
metal parts. Flow chart of fabrication by process. *Hoeganaes Sponge Iron Corp.*

1726. Precision Casting
8-page bulletin on investment castings of various ferrous and nonferrous alloys. *Engineered Precision Casting*

1727. Precision Casting
12-page book on alloy selection and design for precision casting. *Arwood Precision Casting*

1728. Precision Castings
16-page booklet includes composition and properties of carbon, low alloy, stainless, high temperature and tool steel precision castings. *Crucible Steel*

1729. Presses
New 6-page bulletin on 150-ton multipurpose, triple action metalworking press. Features and specifications. *Hydraulic Press Mfg.*

1730. Pure Metals
Data sheets on vacuum melted cobalt, copper, iron and nickel. *Vacuum Metals*

1731. Pyrometer Supplies
New edition of 56-page bulletin P1238 on thermocouples and pyrometer accessories. Engineering data on selection and installation. *Bristol Co.*

1732. Pyrometers
12-page Bulletin 713 on indicating and controlling pyrometers. Functional diagrams of installations. *General Electric*

1733. Quench Agitation
32-page booklet on 1 to 500 hp. mixers, construction, operation, applications. *Mixing Equipment Co.*

1734. Quenching
64-page book tells what happens when steel is heated and cooled, describes quenching media, quenching practices, interrupted quenching and cooling methods. *E. F. Houghton*

1735. Quenching
New bulletin No. 11 on quenching oil also discusses advantages of quench agitation. *Sun Oil Co.*

1736. Quenching
Bulletin 120 on use of heat exchangers to provide heat control in quenching bath. *Niagara Blower*

1737. Quenching Oil
10-page book on new oils for the quenching process gives results on hot wire quench test and in plant operation. *Sinclair Refining Co.*

1738. Quenching Oil
New book on mechanism of quenching, properties of quenching mediums, cooling curves. *Gulf Oil*

1739. Radiation Protection
12-page booklet on films for determining amount of radiation. Used in research laboratories, nondestructive testing laboratories. *Du Pont*

1740. Recorder
8-page bulletin on potentiometer and resistance bridge recorder. *Thermo Electric Co.*

1741. Refractories
Identification guide shows colors that identify the various types of basic refractory brick and lists ramming mixes, bonding mortars and furnace grains. *Kaiser Aluminum & Chemical*

1742. Refractories
New 24-page bulletin on physical and chemical properties of super refractories. Applications. *Refractories Div., Carborundum*

1743. Refractories
8-page bulletin on operating practices with basic-lined cupola gives advantages and mechanics of basic slag systems. *Basic Refractories*

1744. Resistance Testing
Bulletin 100 on production tester for measuring electrical resistance. *Rubicon*

1745. Restorer
8-page catalog R-22 on restorer for detecting and correcting thermocouple circuit failure. *Peerless Electric Co.*

1746. Roll Formed Shapes
24-page Bulletin 1053 on designing, forming and producing shapes from ferrous and nonferrous metals. *Roll Formed Products Co.*

1747. Roll Forming
Bulletin 854 on roll forming of cold rolled shapes. *American Roller Die Corp.*

1748. Rust Preventives
12-page bulletin on water-soluble rust-preventive. *Production Specialties*

1749. Salt Bath Furnaces
Data on salt bath furnaces for batch and conveyorized work. *Upton*

1750. Sand Control
32-page book on defects and troubles in foundry and how to remedy through sand control. *Claud S. Gordon Co.*

1751. Saws
Catalog C-53 describes 35 metal-cutting saws. *Armstrong*

1752. Sheet Polishing
Discussion of new techniques metal polishing. *Acme Mfg. Co*

1753. Shell Molding
8-page booklet No. 2462 on shell molding system for produ 240 molds per hour. *Link-Belt*

1754. Shotblasting
16-page "Primer on the Use of Grit". Problems of blast cleani tions. *Hickman, Williams*

1755. Silver Brazing
48-page manual on all aspect brazing applications and proble *ican Platinum Works*

1756. Sodium
New 28-page booklet on usi in dispersed form tells how are prepared and handled, advantages. *Ethyl Corp.*

1757. Spectrograph
16-page catalog G2-53 describ spectrographs for precision ana *rell-Ash*

1758. Spectrograph
20-page catalog describes lar spectrograph, medium quartz graph and densitometer for analysis. *Bausch & Lomb*

1759. Stainless Casting
8-page bulletin gives recom charts for type of stainless various corrosive solutions, und conditions. *Waukesha Foundry*

1760. Stainless Casting
20-page booklet shows how made, property and size data, t plications. *Crucible Steel*

1761. Stainless Pipe
Bulletin TB-356 gives method ing and joining stainless pipe. D and weights of various types. *B Wilcox*

1762. Stainless Steel
Bulletin shows plates, forgin tank heads, flanges. *G. O. Carls*

1763. Stainless Steel
Slide chart. Set top at a ce ricating operation, bottom sho of each standard grade. On re heat treating and corrosion given. *Carpenter Steel*

FIRS
PERM
(Sec.
Clev

BUSINESS REPLY CARD
No Postage Stamp Necessary If Mailed In the United States

4c POSTAGE WILL BE PAID BY—

METAL PROGRESS
7301 Euclid Avenue
CLEVELAND 3, OHIO

cribes 35 models of
Armstrong-Blum

olishing
techniques for sheet
me Mfg. Co.

olding
o. 2462 on automatic
n for producing up to
Link-Belt Co.

sting
n the Use of Shot and
blast cleaning opera-
liams

Brazing
n all aspects of silver
and problems. *Amer-*
cs

klet on using sodium
tells how dispersions
handled, and their
Corp.

graph
2-53 describes grating
recision analysis. *Jar-*

graph
escribes large Littrow
ium quartz spectro-
ometer for spectrum
Lomb

s Castings
gives recommendation
stainless to use in
lutions, under various
ha Foundry

s Castings
shows how they are
size data, typical ap-
Steel

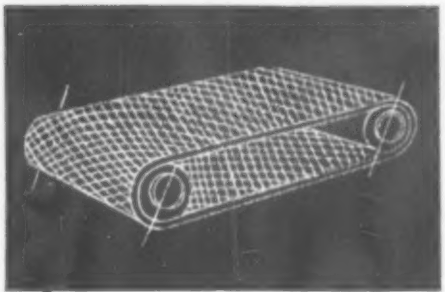
s Pipe
ives methods of bend-
nless pipe. Dimensions
ious types. *Babcock &*

s Steel
lates, forgings, sheets,
G. O. Carlson

s Steel
top at a certain fab-
bottom shows rating
rade. On reverse side,
corrosion data are
teel

FIRST CLASS
PERMIT No. 1595
(Sec. 34.9 P.L. & R.)
Cleveland, Ohio

HOLCROFT and the CONVEYOR FURNACE



STEP UP OUTPUT | **KNOCK DOWN COSTS**

The key word in heat treating today is automation—the handling of stock smoothly, efficiently, without waste. Obvious benefits are boosted production and slashed costs.

Holcroft's answer to automation may be conveyorized furnaces—automatic, not only in stock handling, but with automatically-controlled cycles, too. Each Holcroft installation is custom-engineered to do your job *at the lowest possible cost.*

Conveyor furnaces are almost unlimited in style and application. Single or multi-strand conveyors can be equipped with mesh belts, sheet belts, interlocking links, monorails or pusher chains. Direction of flow can be horizontal, vertical, or in combination—whichever affords the most economic use of available space. Some conveyors are completely inside the furnace—others are integrated into the production line.

Many other types of stock-handling furnaces are available. They're all described in Holcroft's book "Blazing the Heat Treat Trail". Better write for a copy today. Holcroft & Company, 6545 Epworth Blvd., Detroit 10, Michigan.

PRODUCTION HEAT TREAT FURNACES FOR EVERY PURPOSE

CHICAGO, ILL. CLEVELAND, OHIO HOUSTON, TEXAS PHILADELPHIA, PA.

CANADA: Walker Metal Products, Ltd., Windsor, Ontario EUROPE: S.O.F.I.M. Paris 8, France

1764. Stainl
36-page bulleti
of processing at
International Nic

1765. Stainl
Booklet on 43
fabrication. *Shar*

1766. Stamp
New 12-page
drawing, forming
Atwood Mfg.

1767. Stand
48-page public
about 1500 stand
ical, electrical, c
ical. *American S*

1768. Steel
Bulletins on h
420 stainless give
hardening chara

1769. Steel
48-page Handb
and forging stee
ing, cutting and
cribed. *Ohio Sea*

1770. Subz
12-page bulleti
of tool steel an
resulting. *Cincin*

1771. Tank
16 pages of dat
resistant linings
solutions. *Chemi*

1772. Tem
Bulletin 1E-11
applications in li

1773. Testi
16-page bulleti
voltmeters and a
ness scales and
General Electric

1774. Ther
42-page Bulle
couples, radiati
bulbs, accessorie

1775. Ther
44-page catalo
and assemblies
and for special p
Tabular data on
couples. *Leeds &*

1776. Tin
Folder on use

1495	1521	1547
1496	1522	1548
1497	1523	1549
1498	1524	1550
1499	1525	1551
1500	1526	1552
1501	1527	1553
1502	1528	1554
1503	1529	1555
1504	1530	1556
1505	1531	1557
1506	1532	1558
1507	1533	1559
1508	1534	1560
1509	1535	1561
1510	1536	1562
1511	1537	1563
1512	1538	1564
1513	1539	1565
1514	1540	1566
1515	1541	1567
1516	1542	1568
1517	1543	1569
1518	1544	1570
1519	1545	1571
1520	1546	1572

4. Stainless Steel
page bulletin on effect on properties rocessing at different temperatures. national Nickel

5. Stainless Steel
oklet on 430 stainless. Properties, cation. *Sharon Steel*

6. Stamping
w 12-page catalog on stamping, ing, forming and heading. *Plume & ood Mfg.*

7. Standards Index
page publication lists and indexes t 1500 standards, including mechan- electrical, chemical and metallurg- *American Standards Assoc.*

8. Steel
lletins on hot work steel and Type tainless give forging, annealing and ening characteristics. *Firth Sterling*

9. Steel Tubing
page Handbook F-3 on fabricating forging steel tubing. Bending, shap- cutting and joining operations de- d. *Ohio Seamless Tube*

0. Subzero Treatment
page bulletin on subzero treatment ool steel and increase in tool life ting. *Cincinnati Sub-Zero Products*

1. Tanks and Linings
pages of data on tanks and corrosion- tant linings for cleaning and plating tions. *Chemical Corp.*

2. Tempering
lletin 1E-11 on tempering and other ications in liquid baths. *Kemp*

3. Testing Instruments
page bulletin on portable recorders, neters and ammeters, surface rough- scales and other electric testers. *ral Electric*

4. Thermocouple Data
page Bulletin TC-9 on thermo- les, radiation detectors, resistance s, accessories. *Wheelco*

5. Thermocouples
page catalog EN-S2 describes couples assemblies for general application for special plant and laboratory uses. lar data on accuracy and limits of les. *Leeds & Northrup*

6. Tin
lder on uses of tin for lubricating, as a fusing agent, barrier, opacifier, fixative, stabilizer, pesticide. *Malayan Tin Bureau*

1777. Tin Plate
Data on immersion method of applying a pure tin coating on brass or copper. *Technic*

1778. Titanium Bolt
Bulletin 1473 contains chart and table of fatigue properties of titanium tension bolt. *Standard Pressed Steel*

1779. Titanium Tubing
Bulletin No. 42 on properties, applications and advantages of titanium tubing. *Superior Tube Co.*

1780. Titanium Tubing
Two grades of titanium tubing and pipe. Corrosion resistance, machining characteristics, forming, welding, heat treating and cleaning. *Carpenter Steel Co., Alloy Tube Div.*

1781. Tool & Die Steels
28-page guide to qualities and sizes available. *Uddeholm*

1782. Tool Steel Color Guide
Color guide to estimate temperatures has heat colors on one side and temper color on the other. *Bethlehem Steel*

1783. Tool Steels
Bulletin on tool steels, hot work specialty steels, bar stock, billet, sand casting, drill rod, flat ground stock and tool bits. *Darwin & Milner, Inc.*

1784. Tungsten
20-page bulletin on manufacture, properties and uses of tungsten. Flow chart of tungsten production. *Sylvania Electric Products*

1785. Ultrasonic Cleaning
Folder on Sonogen ultrasonic generator for metal cleaning. *Branson*

1786. Ultrasonic Testing
Bulletin on testing equipment for measuring thickness, lack of bond, laminar-type defects. *Magnaflux*

1787. Vacuum Pumps
Data sheets on 4, 6, 10, and 16 in. ring-jet booster pumps. *Stokes*

1788. Vacuum Pumps
New Bulletin 400 on mechanical booster high vacuum pumps. *Kinney Mfg. Div.*

1789. Valves
50-page booklet on valves for the process industries. *Gas Machinery*

1790. Vanadium in Steel
189-page book on properties of ferrous alloys containing vanadium and their applications. *Vanadium Corp.*

1791. Water Softeners
20-page bulletin 2386-A on water softeners. Specifications, operating characteristics and typical installations. *Permutit*

1792. Welding
10-page bulletin on welding technique involving use of weld insert. *Arcos*

1793. Welding Equipment
Catalog on Cadweld process and arc-welding accessories. *Erico Products*

1794. Welding Magnesium
Article on inert-gas-shielded metal-arc welding of magnesium includes numerous illustrations and tables of data. *Dow Chemical*

1795. Welding Rods
Catalog lists metals, alloys, powdered metals and processed minerals and ores for the welding rod industry. *Shieldalloy*

1796. Welding Stainless
New 48-page booklet describes various electrodes used on stainless steel. General description of welding process. *McKay Co.*

1797. Welding Stainless
Data card 162 on the welding of stainless tubing and pipe. *Babcock & Wilcox*

1798. Wire and Ribbon
New 12-page booklet describes manufacture of fine wire and ribbon, wire and ribbon parts and small parts plating. *Sylvania Electric, Parts Div.*

1799. Wire Belts
Folder on control mechanism for use with woven wire belts. *Knapp Mills, Inc., Guidler Div.*

1800. Wire Cloth
84-page booklet on applications, meshes, baskets, filters. *Cambridge Wire Cloth*

1801. Wire Patenting
Bulletin A-105 on continuous patenting, cleaning and coating of steel wire. *Gas Machinery*

1802. X-Ray Diffraction
Bulletin 8A-3505 on film or direct recording X-ray diffraction apparatus. *X-Ray Div., General Electric*

1803. X-Ray Equipment
12-page booklet on 250-KV constant potential X-ray equipment for internal inspection. Advantages design features. *Westinghouse Electric*

June, 1955

1521	1547	1573	1599	1625	1651	1677	1703	1729	1755	1781
1522	1548	1574	1600	1626	1652	1678	1704	1730	1756	1782
1523	1549	1575	1601	1627	1653	1679	1705	1731	1757	1783
1524	1550	1576	1602	1628	1654	1680	1706	1732	1758	1784
1525	1551	1577	1603	1629	1655	1681	1707	1733	1759	1785
1526	1552	1578	1604	1630	1656	1682	1708	1734	1760	1786
1527	1553	1579	1605	1631	1657	1683	1709	1735	1761	1787
1528	1554	1580	1606	1632	1658	1684	1710	1736	1762	1788
1529	1555	1581	1607	1633	1659	1685	1711	1737	1763	1789
1530	1556	1582	1608	1634	1660	1686	1712	1738	1764	1790
1531	1557	1583	1609	1635	1661	1687	1713	1739	1765	1791
1532	1558	1584	1610	1636	1662	1688	1714	1740	1766	1792
1533	1559	1585	1611	1637	1663	1689	1715	1741	1767	1793
1534	1560	1586	1612	1638	1664	1690	1716	1742	1768	1794
1535	1561	1587	1613	1639	1665	1691	1717	1743	1769	1795
1536	1562	1588	1614	1640	1666	1692	1718	1744	1770	1796
1537	1563	1589	1615	1641	1667	1693	1719	1745	1771	1797
1538	1564	1590	1616	1642	1668	1694	1720	1746	1772	1798
1539	1565	1591	1617	1643	1669	1695	1721	1747	1773	1799
1540	1566	1592	1618	1644	1670	1696	1722	1748	1774	1800
1541	1567	1593	1619	1645	1671	1697	1723	1749	1775	1801
1542	1568	1594	1620	1646	1672	1698	1724	1750	1776	1802
1543	1569	1595	1621	1647	1673	1699	1725	1751	1777	1803
1544	1570	1596	1622	1648	1674	1700	1726	1752	1778	
1545	1571	1597	1623	1649	1675	1701	1727	1753	1779	
1546	1572	1598	1624	1650	1676	1702	1728	1754	1780	

METAL PROGRESS,

7301 Euclid Avenue, Cleveland 3, Ohio

Please have literature circled at the left sent to me.

Name

Title

Company

Address

City and State

Postcard must be mailed prior to Sept. 1, 1955
Students should write direct to manufacturers.

BIG BROTHER TO A DENTAL DRILL

"Painless," efficient drilling of primary blast holes in the earth's rock crust—by either percussion or rotary action—is a cinch for Ingersoll-Rand's heavy-duty Quarrymaster. But its greatest advantage lies in the built-in hole cleaner, made possible by using B&W Mechanical Tubing for the drill rod. An automatic, continuous stream of compressed air is forced down through the tubular drill rod to the bit and back up, between drill rod and casing, to the surface, carrying the cuttings with it. And this hollow drill rod has been proved stronger, lighter and more rigid than a solid bar.

To satisfy vital requirements such as long life under extreme conditions of impact, B&W imparted desirable cold-worked properties to this tubing and also devised a special hot-upsetting procedure. With Quarrymasters now in service all over the world, the effectiveness of their drill rods made of B&W Mechanical Tubing has long since been decisively demonstrated.

B&W
TUBULAR PRODUCTS DIVISION

THE BABCOCK & WILCOX COMPANY
TUBULAR PRODUCTS DIVISION
Beaver Falls, Pa. and Milwaukee, Wis.: Seamless Tubing, Welded Stainless Steel Tubing
Alliance, Ohio: Welded Carbon Steel Tubing
Milwaukee, Wis.: Seamless Welding Fittings

For a comprehensive story of how B&W Mechanical Tubing serves many industries, ask for Technical Bulletin 361 MP

TA-5005(M)

------ Hayes leadership

WORLD'S LARGEST ELECTRIC

with capacity for heating 10 tons of billets for forging

As Maj. General Nathan Bedford Forrest, Confederate Army, said:

"Get thar fustest with the mostest"

WELL, LET'S SEE

The small furnace in the foreground, opposite, is the first controlled-atmosphere furnace ever sold to American Industry.

Guess that's "fustest"

The large furnace is, we believe, the largest high temperature (2400°F.) controlled atmosphere furnace in the world.

Guess that's "mostest"

BOTH DESIGNED AND BUILT BY C. I. HAYES INC.

HAYES' NEW PLANT

Occupied in September, 1954, this plant quadruples our capacity for building "Certain Curtain" furnaces, and facilitates handling of large units like the one opposite.

One of two 360-foot straight-through assembly floors, with materials and sub-assemblies feeding in from the sides.

Whatever your furnace needs for control—

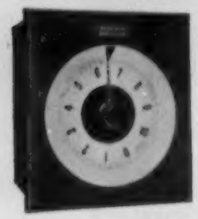
There's good reason why more heat-treating furnaces everywhere are controlled by Brown instruments. First, of course, is performance . . . sensitive, precise control that meets the most exacting requirements of modern heat-treating techniques. And equally important is versatility. In this varied line of instrumentation you'll find just about everything a furnace could possibly need in the way of control.

Choose *ElectroniK* Strip Chart Controllers for detailed, long-term records . . . and a selection of control forms including electric systems of the contact, position-proportioning (*Electr-O-Line*) and time-proportioning (*Electr-O-Pulse*) types; and pneumatic control from two-position to full proportional-plus-reset-plus-rate action

Choose *ElectroniK* Circular Chart Controllers for ease of scale reading . . . convenient daily charts; in a full range of electric and pneumatic control forms.

Note: the basic components of all *ElectroniK* models are interchangeable . . . to simplify and speed up service.

Choose *ElectroniK* Circular Scale Controllers where you want readability and control check at extreme distance . . . without need for a record. Supplied with all contact and proportional types of electric control.



Note: all *ElectroniK* models are available in both Standard and Precision Series.

Choose *Pyr-O-Vane* Controllers where you don't need a record but do need precise vane type snap action electric control by a millivoltmeter instrument... also available with pulse-type time proportioning action, in both vertical and horizontal models.

Choose the *Protect-O-Vane* Safety Cut-Off for simple, dependable excess temperature protection ... can be used with any temperature control to prevent furnace shut downs and loss of production.

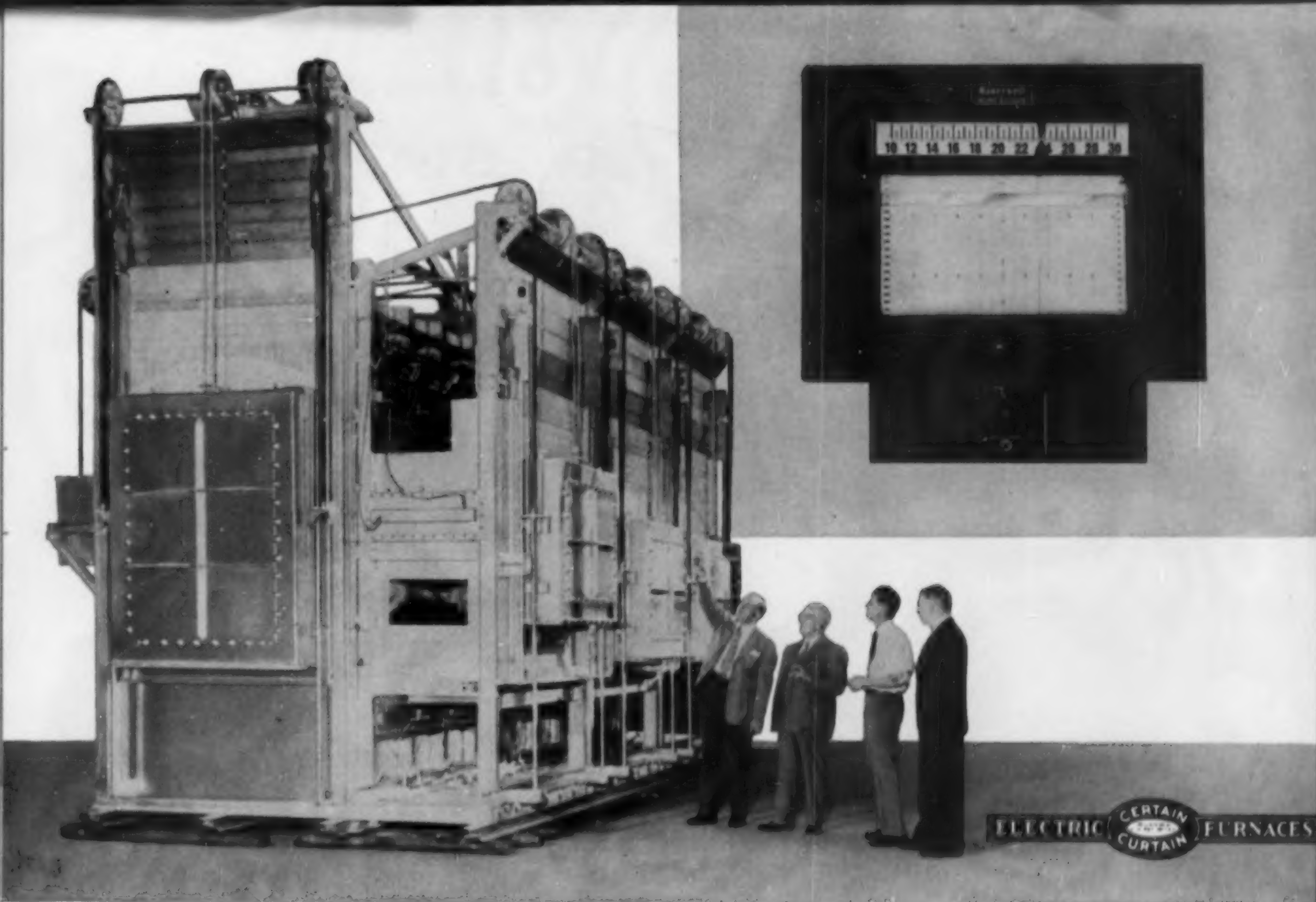
• • •

And for all your pyrometer supplies, investigate the convenience and economy advantages of the HSM Plan.

Product of the engineering skill of C. I. Hayes, Inc., of Cranston, R. I., this giant furnace has a heating chamber 19' long, 8' 2" high and 4' wide.

World's largest electric steel forging furnace

Listed in Catalog 1531 are the varied types of ElectroniK Controllers . . . including electric and pneumatic systems affording a broad selection of control action. Write for your copy.


ELECTRIC
CERTAIN CURTAIN
FURNACES

Crowning

30 YEARS OF "TEAMWORK"

between...

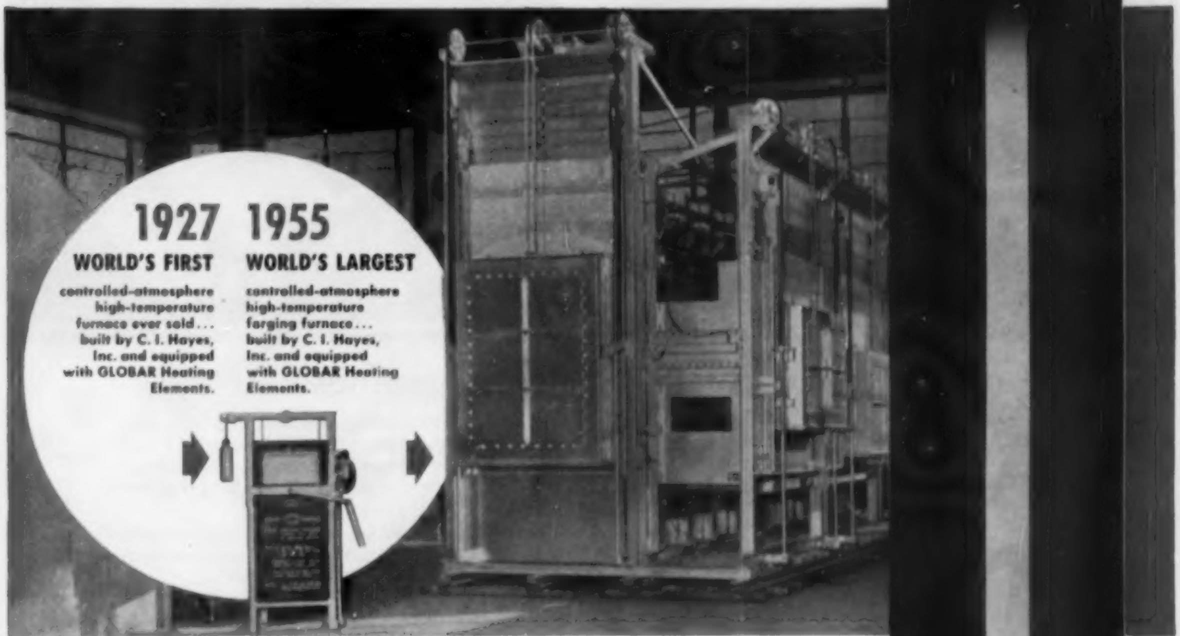
C. I. HAYES, INC.

ELECTRIC CERTAIN CURTAIN FURNACES

and...

GLOBAR®

HEATING ELEMENTS



We're proud to be a part of this biggest furnace of its kind, built by C. I. Hayes, Inc. for the Wyman Gordon Company. Here is the strongest possible testimony of what we have been practicing and preaching for the past 30 years: nowhere but at GLOBAR Division can you find so powerful a combination of product quality and engineering "know-how" to help solve your industrial heating problems. That's why C. I. Hayes, Inc., and the other major furnace builders, year after year, specify GLOBAR Heating Elements.

Whether your problem is forging, annealing, brazing or sintering, here you see a continuing demonstration of the fact that a well-designed electric furnace is the best furnace for industrial processes — especially when it's equipped with...

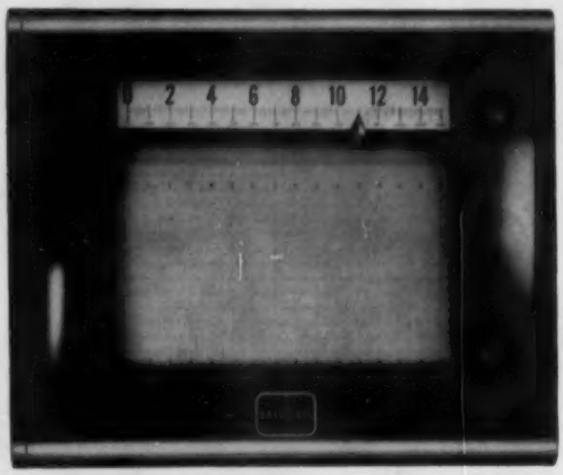
...those dependable, long-life **GLOBAR®** *Heating Elements*

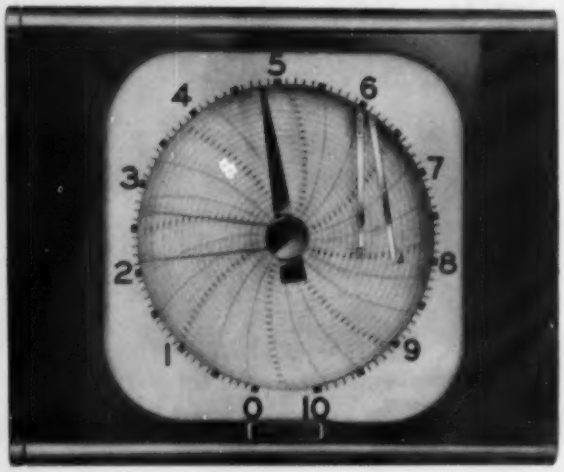
by CARBORUNDUM

REGISTERED TRADE MARK

WHAT'S NEW AT BRISTOL...

Three Ways to Better Temperature Control





BRISTOL ELECTRONIC DYNAMASTER® POTENTIOMETERS

CONTINUOUS STANDARDIZATION WITH NO DRY CELLS: Bristol Dynamaster Potentiometers with No-Batt Continuous Standardization which eliminates need for dry cells. Results: no interruption in operation for standardization, no batteries to replace.

A MODEL FOR EVERY REQUIREMENT: Dynamaster Potentiometers are available as single-pen, two-pen, and multiple-record (up to 24 points) *strip-chart* instruments and as *round-chart* instruments.

ELECTRIC AND PNEUMATIC CONTROLLERS. Both strip- and round-chart instruments are made in a very wide variety of controllers that meet every furnace and oven control requirement, including the following in a great many forms:

Electric Control — on-off, average position, proportional input, 3-position, proportioning, proportional with automatic reset, and time-program.

Pneumatic Control — on-off, proportional, and proportional with reset.

FREE-VANE® ELECTRONIC PYROMETER CONTROLLERS

- **Very minute changes in temperature** at the control point (less than 0.003" on scale) closes or opens the Thyratron-operated relay with positive trigger action.
- **New high-torque, rugged millivoltmeter measuring mechanism** gives greater accuracy — Alnico V magnet — and a sensitivity of 15 ohms per millivolt.
- **Separate control units are plug-in.**
- **Wide variety of models** — available in thermocouple and radiation pyrometer controllers in ranges up to 4000°F for L, H, LH, LOH, and LNH control and for L and H with proportional input control.

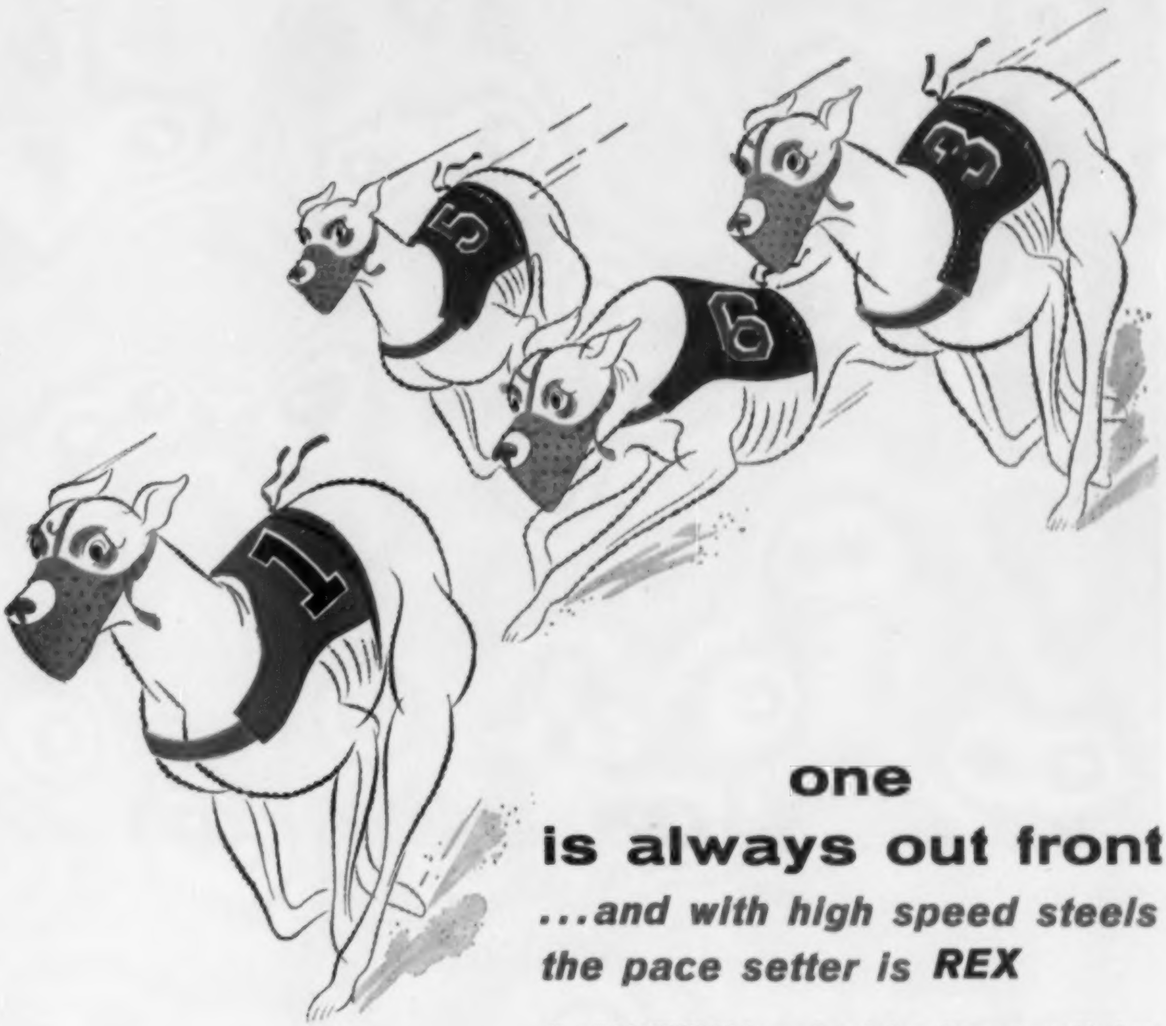
FOR MORE FACTS about these three rugged Bristol Furnace and Oven Controls write for free Bulletin P1260 today. It's a 48-page booklet of useful data, specifications, control diagrams and prices for every type of automatic heating control. The Bristol Company, 106 Bristol Road, Waterbury, Conn. 5.5

BRISTOL'S

BRISTOL

POINTS THE WAY IN HUMAN-ENGINEERED INSTRUMENTATION

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS



one
is always out front
...and with high speed steels the pace setter is REX

Crucible's REX high speed steels have been way out in front ever since their introduction. And today they're still the *standard for comparison* wherever high speed steels are used.

There are many good reasons for REX's leadership — uniformity of size, structure, finish, response to heat treatment, tool performance. Each factor can be proved in your own shop, on your own work. So try this *standard for comparison* on a few jobs and you'll agree with thousands of users — *you can't find a high speed steel to outperform REX.*

Because of its extensive, nationwide use, REX high speed steel is carried in stock by the coast-to-coast chain of Crucible warehouses, or is available on quick mill delivery. *Crucible Steel Company of America, Henry W. Oliver Building, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

"WHY. . .why does it cost us so much to make this?"

How many times have you asked this question? A simple part, an assembly or a finished product — why should it cost so much to make? Why? Maybe one answer is so obvious it's being overlooked.

This may be an answer

Invisible cracks developing in parts during manufacture are too often the cause of these high costs. It isn't the cost of the rough parts themselves. It's the time and labor that go into them . . . setting up, machining, finishing . . . all to be scrapped at final inspection.

You don't have to accept this loss as "fixed." Inspection with Magnaflux during manufacture finds *all* cracks when they first occur — suggests the cause and how it can be corrected — *before* parts are run in quantity. Before the bad ones raise your product costs to the point where you ask "Why?"

Ask to have one of our engineers show you how inspection with Magnaflux can save you money — or write for new booklet on LOWER MANUFACTURING COST.

MAGNAFLUX

MAGNAFLUX CORPORATION
7346 West Lawrence Avenue • Chicago 31, Illinois
New York 36 • Pittsburgh 36 • Cleveland 15
Detroit 11 • Dallas 19 • Los Angeles 58

3 POINTS TO REMEMBER

sodium hydride descaling is:

FAST------


PRODUCTIVE-----


POSITIVE---------


And economy makes four... four major reasons you'll want to investigate the advantages of sodium hydride descaling.

This versatile method descales a wide range of metals and alloys in only minutes. And with compact, low-cost, easily maintained equipment. No problem of waste disposal or of metal pitting. Unlike pickling, sodium hydride descaling never attacks base metal... acts uniformly on crevices and high spots alike.

If you already have a hydride descaling unit, Ethyl offers you a dependable, continuing supply of high quality sodium to operate it. If you'd like to install one, we can help there, too. With suggestions, recommendations, estimates that will put this advanced, highly efficient method to work for you promptly.

For lower labor costs, higher production, more positive descaling, mail this coupon today.

For Titanium, Carbon and Alloy Steels, Stainless Steels, High Speed Tool Steels, Cast Iron, Nickel, Inconel, Copper, Silver, Stellite.

ETHYL CORPORATION

100 PARK AVENUE, NEW YORK 17, NEW YORK

ATLANTA, BATON ROUGE, CHICAGO, DALLAS, DAYTON, DENVER, DETROIT, HOUSTON, KANSAS CITY, LOS ANGELES, NEW ORLEANS, PHILADELPHIA, PITTSBURGH, SALT LAKE CITY, SAN FRANCISCO, SEATTLE, TULSA, MEXICO CITY AND (ETHYL ANTIKNOCK, LTD.) TORONTO.

ETHYL
SODIUM METALLIC
ETHYL CORPORATION

ETHYL CORPORATION
100 Park Avenue, New York 17, N.Y.

Please send me brochure on Sodium Hydride Descaling describing its uses, advantages, typical reactions and necessary equipment.

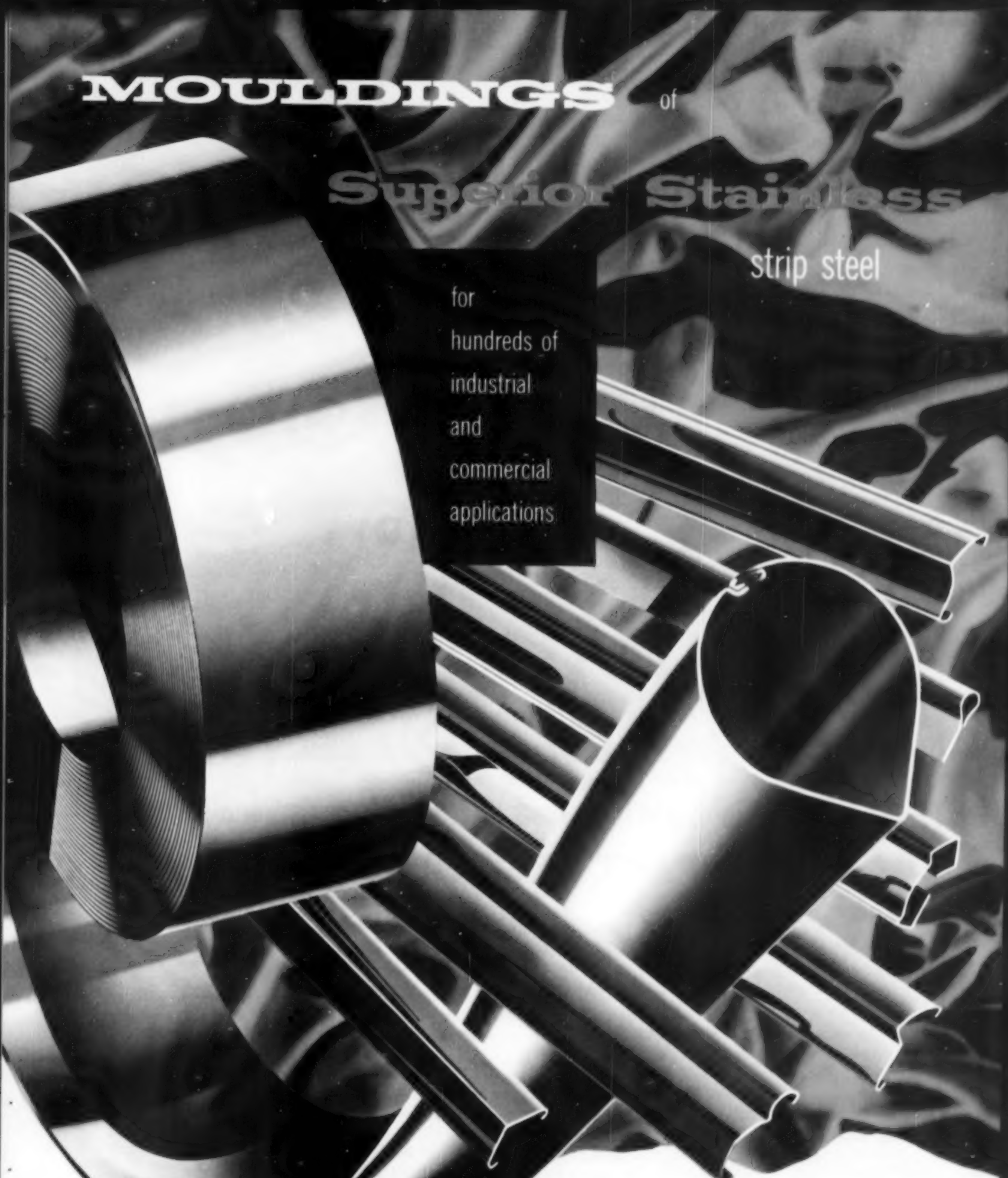
NAME ____________________

FIRM ____________________

ADDRESS ____________________

CITY ____________________ STATE ________

MP6-55



Here's *usable beauty* for exacting service . . . wear-resistant, hard, bright and strong throughout! SUPERIOR STAINLESS forms smoothly and easily because it is uniform in every physical quality: facts proved by the mile in mouldings manufacture every day. • May we serve *your* stainless steel strip applications?

Superior Steel
CORPORATION
CARNEGIE, PENNSYLVANIA

Metal Progress

BULLETIN BOARD

THE BUYERS GUIDE FOR METALS ENGINEERS

For positive blackening of steel and iron parts . . .
USE SWIFT BLACK!
For efficient metal cleaning
USE SWIFT METAL CLEANING COMPOUNDS!
For certain rust prevention
USE SWIFT RUST PREVENTATIVES!
For heat treating
USE SWIFT SALT BATH!
For quenching
USE SWIFT QUENCHING OILS!

Send TODAY for descriptive literature and technical data sheets.

Swift
INDUSTRIAL CHEMICAL CO.
Canton Connecticut

LIST NO. 92 ON INFO-COUPON PAGE 60

WELDCO

FABRICATED MONEL PICKLING EQUIPMENT

• Hairpin Hooks • Sheet Crates
• Steam Jets • Chain
• Mechanical Bar, Tube and Coil Picklers

THE YOUNGSTOWN WELDING & ENGINEERING CO.
3721 OAKWOOD AVE. YOUNGSTOWN, OHIO

LIST NO. 94 ON INFO-COUPON PAGE 60

RUST-LICK
IN
AQUEOUS SYSTEMS

Grade "C-W-25"
Non-flammable
Non-toxic
Aqueous Oily Film
Protects Ferrous Parts
for Long Periods
Indoor Storage

Write for free sample and brochure
Specify Grade "C-W-25"

PRODUCTION SPECIALTIES, INC.
755 BOYLSTON STREET
BOSTON 16, MASS.

LIST NO. 121 ON INFO-COUPON PAGE 60

CIRCO Metal Cleaning Equipment CUTS costs

SINCE 1923

CiRCO

EQUIPMENT COMPANY
122 Central Avenue, Clark (Rahway), N. J.
Offices and warehouses in principal cities

CIRCO VAPOR DEGREASERS—large or small—automatic or manual operation

CIRCO METAL PARTS WASHERS—custom engineered to suit your production needs

CIRCO-SONIC DEGREASERS — newest development—cleaning by ultrasonic vibration

CIRCO-SOLV (Trichlorethylene) and PER-SOLV (Perchlorethylene) — high purity, low-cost solvents

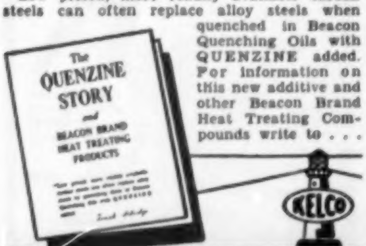
FREE! Write for 32-page CIRCO Degreasing Manual

LIST NO. 10 ON INFO-COUPON NO. 60

FREE

the QUENZINE STORY

Low priced, more readily available carbon steels can often replace alloy steels when quenched in Beacon Quenching Oils with QUENZINE added. For information on this new additive and other Beacon Brand Heat Treating Compounds write to . . .



KELCO

ALDRIDGE INDUSTRIAL OILS, Inc.
3401 W. 140th St., Cleveland 11, Ohio

LIST NO. 29 ON INFO-COUPON PAGE 60

BASKETS
for all industrial requirements

for de-greasing — pickling
anodizing — plating
materials handling
small-parts storage

of any size and shape —
any ductile metal

by
THE C. O.
JELLIFF
MFG. CORP.
28 Pequot Road
Southport, Conn.

WIRE PRODUCTS
Jelliff
SINCE – 1880

LIST NO. 91 ON INFO-COUPON PAGE 60

GARDEN CITY Industrial FANS

For a wide choice . . . GARDEN CITY FANS designed with FORWARD — BACKWARD — or RADIAL BLADES, serve many industrial processing requirements.

If your needs call for HIGH TEMPERATURES (300° to 1600°F) you'll find GARDEN CITY HIGH TEMPERATURE FANS save you money. Patented air-cooled shaft slices maintainence costs.

Send for our latest catalogs, illustrating GARDEN CITY INDUSTRIAL FAN equipment. For specific details, outline your fan problems to us, giving cubic feet per minute, static pressure, and just how you intend to use the fan. We'll be pleased to suggest a fan for you.

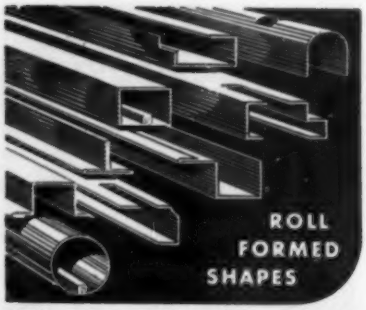
GARDEN CITY FAN COMPANY

332 South Michigan Avenue — Chicago 4, Illinois

Representatives in principal cities

OUR DIAMOND 75th ANNIVERSARY

LIST NO. 123 ON INFO-COUPON BELOW



Reduce your assembly problems and costs. Our shapes continuously formed, with high degree of accuracy, from ferrous or nonferrous metals. Write for Catalog No. 1053.

ROLL FORMED PRODUCTS CO.

MAIN OFFICE AND PLANT
3761 OAKWOOD AVE. • YOUNGSTOWN, OHIO

NO. 101 ON INFO-COUPON BELOW

ARDCOR *Engineered*

TUBING ROLLS
AND
FORMING ROLLS

To Your Specifications or Ardcor Design—for all makes of machines

DESIGNERS AND MANUFACTURERS: All Sizes and Spindle Diameters of Roll Forming Machines, Welded and Lock-Seam Pipe and Tube Mills • Forming Rolls, Tubing and Pipe Rolls • Straightening, Pinch and Leveller Rolls • Cut-off Machines

American ROLLER DIE CORPORATION

29550 Clayton Avenue • Wickliffe, Ohio

LIST NO. 57 ON INFO-COUPON BELOW

WHITELIGHT
MAGNESIUM

your comprehensive independent source of magnesium alloy Tubes • Rods • Shapes • Bars Hollow Extrusions • Plate • Sheet • Pipe • Wire • Welded and Riveted structures and assemblies

WHITELIGHT MAGNESIUM

WHITE METAL ROLLING & STAMPING CORP.

82 Moultrie St., Brooklyn 22, N. Y.

Sales Office
376 Lafayette St., New York 3, N. Y.

LIST NO. 67 ON INFO-COUPON BELOW

READERS' INFO-COUPON SERVICE, METAL PROGRESS
7301 Euclid Avenue, Cleveland 3, Ohio

Please send further information, as checked at the right, on the advertisements in the Bulletin Board with numbers I have listed below—

(Bulletin Board Item Number)	Send Catalog or Engineering Data	Send Price Info	Nearest Source of Supply
______	☐	☐	☐
______	☐	☐	☐
______	☐	☐	☐
______	☐	☐	☐
______	☐	☐	☐

(Please check)

Your Name ______ Title ______

Company ______

Street ______

City ______ Zone ______ State ______

Are parts machined for you under **STATISTICAL QUALITY CONTROL?**

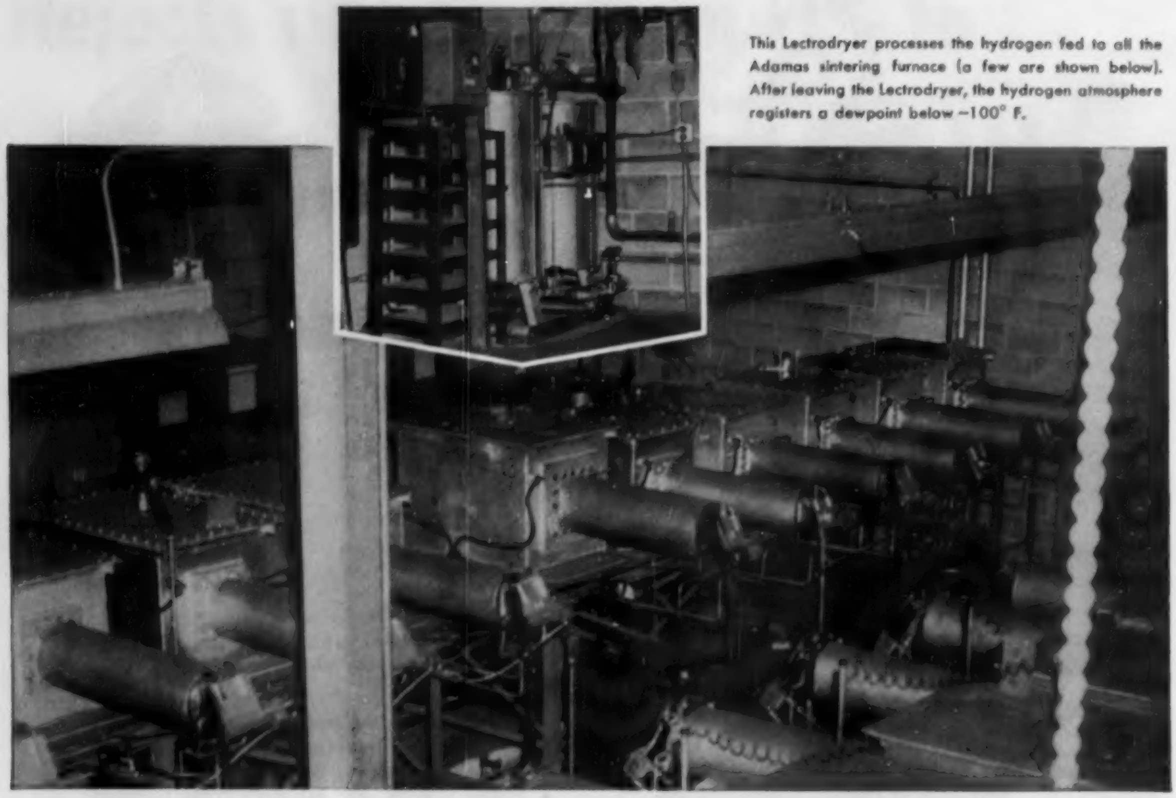
At Non-Gran, they will be. Our contract machine work is performed under industry's newest approach to better products, at lower cost. Write! **AMERICAN NON-GRAN BRONZE CO., BERWYN, PA.** *Metropolitan Philadelphia.*

PRECISION MACHINE WORK — NON-GRAN — CASTINGS • SAND & CENTRIFUGAL

Write for book "Our Story in Pictures"

LIST NO. 3 ON INFO-COUPON AT LEFT

This Lectrodryer processes the hydrogen fed to all the Adamas sintering furnace (a few are shown below). After leaving the Lectrodryer, the hydrogen atmosphere registers a dewpoint below −100° F.



Adamas Carbide insists on DRY hydrogen for sintering

A hydrogen dried to a dewpoint below −100° F prevents surface oxidizing of carbides being sintered at Adamas Carbide Corporation's ultramodern plant at Kenilworth, New Jersey.

To obtain such dryness, Adamas follows two steps:

(1) The hydrogen feeds through a catalytic cylinder which converts every trace of free oxygen into moisture.

(2) Then the hydrogen passes through a Lectrodryer* which snatches moisture from the gas, delivering it at a dewpoint somewhere below −100° F.

You can obtain similar dryness

Lectrodryers will economically remove unwanted moisture from air or other gases in a continuous, automatic cycle. For large or small volume—low or high pressures (to 6000 psi)—Lectrodryers of all types and sizes are available to solve your problem.

Talk it over with a Lectrodryer engineer. No obligation, and he may help you considerably. Write for the booklet, *Because Moisture Isn't Pink*, describing how industry is using Lectrodryers. Pittsburgh Lectrodryer Corporation, 317 32nd Street, Pittsburgh 30, Pa.

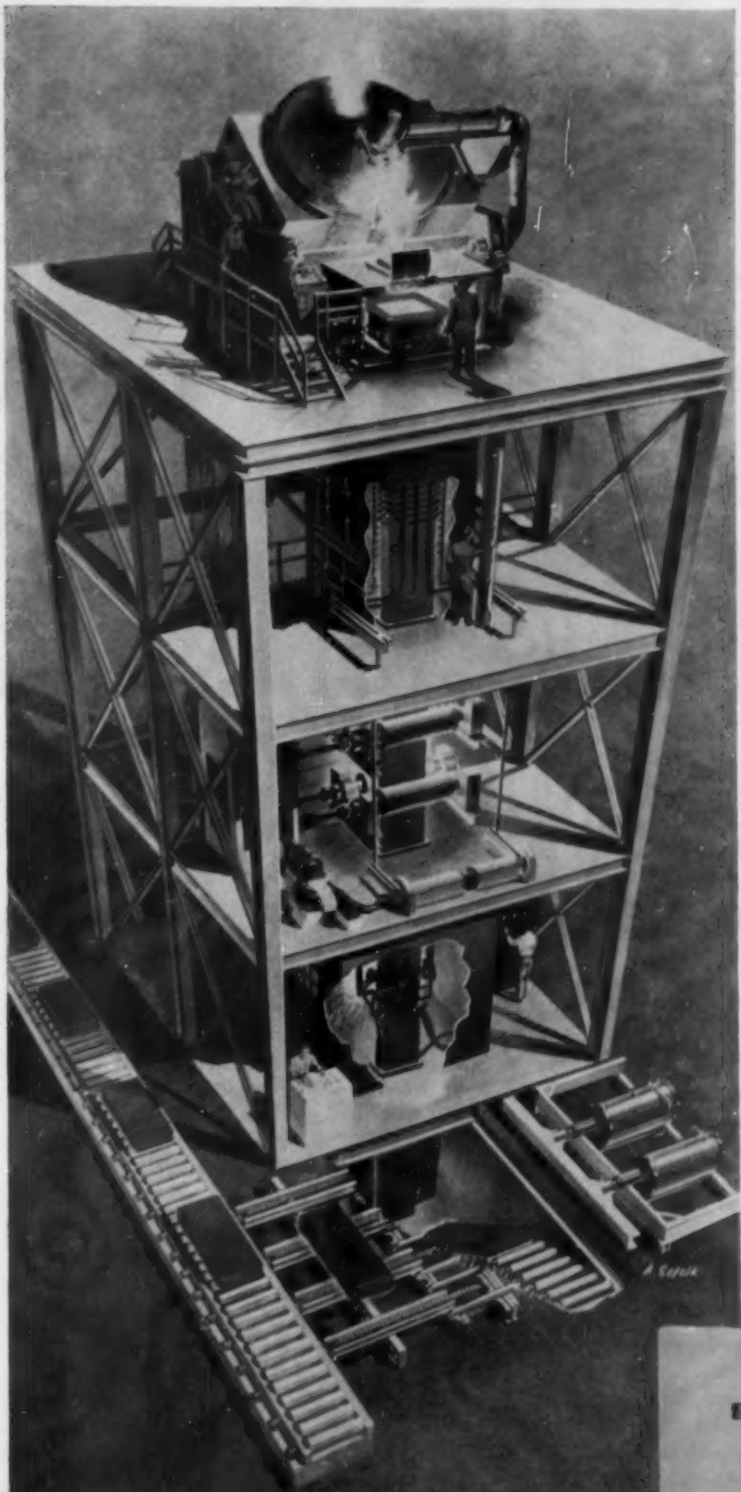
In England: Birlec, Limited, Tyburn Road, Erdington, Birmingham.
In France: Stein et Roubaix, 24 Rue Erlanger, Paris XVI.
In Belgium: S. A. Belge Stein et Roubaix, 320 Rue du Moulin, Bressoux-Liege.

LECTRODRYERS DRY WITH ACTIVATED ALUMINAS

LECTRODRYER

* REGISTERED TRADEMARK U.S. PAT. OFF.

For the continuous casting of steel...



Koppers builds the first commercial-scale machine

The continuous-casting machine illustrated here is now in operation at Atlas Steels Ltd., Welland, Ontario, Canada. This is the first commercial-scale installation in North America that, in a continuous line, converts molten steel into solidified billets or slabs. It was designed and constructed by the Freyn Department of Koppers Engineering and Construction Division.

Atlas Steels' machine is presently producing slabs and billets in three sizes. With different molds, this machine also could produce any desired billet section. It is designed to cast 35-ton heats.

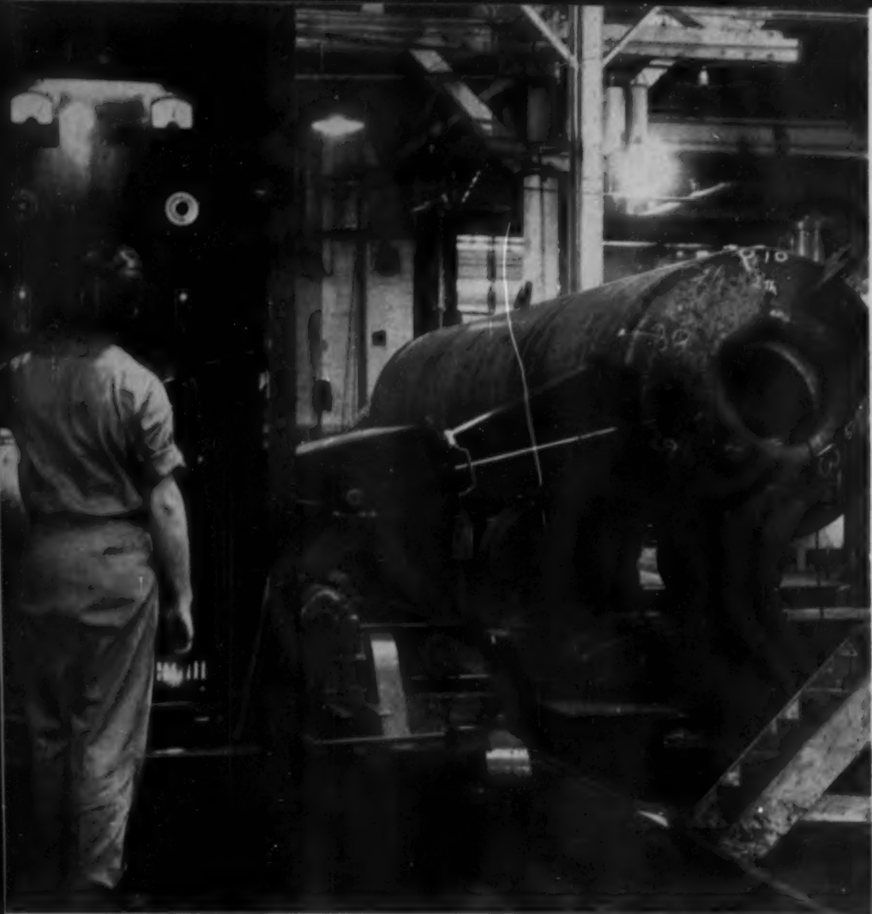
In theory, this new machine could cast a billet or slab of steel many miles in length; it is limited only by the supply of molten metal. In actual practice, acetylene torches automatically cut the molded steel into required lengths as it emerges from the machine.

Continuous casting is an *economical* short-cut in steelmaking. It eliminates the need for ingot-casting and stripping equipment, except the ladle crane. Soaking pits and blooming mills can be by-passed. Also, the Freyn-design continuous-casting process can yield 10 to 15 per cent more finished steel per heat than conventional pouring methods.

Your inquiry is invited concerning the continuous-casting operation . . . or any other metallurgical construction problems you may have. You incur no obligation.

KOPPERS ®

KOPPERS COMPANY, INC.
Engineering and Construction Division
FREYN DEPARTMENT
Pittsburgh 19, Pennsylvania



Beginning the series of exposures on a welded boiler seam at Wickes. In accordance with the ASME Code, every inch of heavy boiler weld is checked. Du Pont X-ray Film is used.

Du Pont Technical Representative Dick Aubrey examines a finished film with Plant Superintendent Lyman. Aubrey is a regular visitor — checking Wickes' film supply, helping with technical problems.

Freshly processed Du Pont Film is removed from the wash by Radiographer Fred Siecker. Thorough washing, plus high quality of the Du Pont emulsion, insures long record life.

"Blue-based Du Pont X-ray Film is easier to read . . . keeps its quality through years of storage,"

says Plant Superintendent Robert Lyman, Wickes Boiler Company Division, Wickes Corporation, Saginaw, Mich.

"Wickes Corporation x-rays over 14,000 linear feet of boiler weld each year on Du Pont X-ray Film! Reading that much film *could* be a tedious, difficult job. But thanks to the high contrast and blue-tinted base of Du Pont Film, interpretation is no strain at all.

"Not only is Du Pont X-ray Film easy to read when it's freshly processed . . . it retains that quality through many years of storage in our files. We never know when we'll have to refer to one of our filed radiographs. So, it's important that *all* of them stay in perfect condition.

"With the checking and cross checking of films that's involved in weld examinations, the film we use must be consistent in speed and contrast. That's another big reason why we stick with Du Pont . . . we've never found another film that approaches it for box-after-box consistency."

If clear-cut analysis and unsurpassed stability are essential in your operation, you'll want to standardize on Du Pont X-ray Film. For samples to test in your own plant, contact your Du Pont Technical Representative or local District Office.

FOR MORE INFORMATION, contact the nearest Du Pont District Office (listed below) or the Du Pont Company, Photo Products Department, Wilmington 98, Del. In Canada: Du Pont Company of Canada Limited, Montreal.

DISTRICT OFFICES

Atlanta 5, Ga.	805 Peachtree Building
Boston 10, Mass.	140 Federal Street
Chicago 18, Ill.	3289 N. California Avenue
Cleveland 14, Ohio	1033 Union Commerce Bldg.
Dallas 7, Texas	1628 Oak Lawn Avenue
Los Angeles 38, Calif.	7051 Santa Monica Boulevard
New York 11, N. Y.	248 West 18th Street
Philadelphia 2, Pa.	225 South 15th Street
Export	Nemours Bldg., Wilmington 98, Delaware
Canada	Du Pont Company of Canada Limited, Montreal

DU PONT

REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING
. . . *THROUGH CHEMISTRY*

SPECIFY DU PONT X-RAY PRODUCTS

FILMS • "PATTERSON" SCREENS • CHEMICALS

"Failure to reach Rc 44-46 almost cost them the contract!"

A well-known commercial metal-treating plant in Milwaukee was having great difficulty fulfilling a contract for treating 1085 carbon steel. "Their chief metallurgist told me every other oil they had tried failed to quench the metal to desired specifications – and they were close to losing the contract," reports Sinclair's Representative H. F. Long. "Among other requirements, was a Rockwell C hardness specification of 44 to 46. The best obtainable with the oils tried was Rc 35.

QUENCHOL 521 Recommended...

A special hardness demonstration of Sinclair QUENCHOL 521 prompted these people to arrange for immediate tests. We installed QUENCHOL 521 in a large Lindberg furnace having an oil capacity of 400 gallons. Production-wise, the tests showed that a Rockwell C hardness (as quenched) of 62 to 64 was easily attainable. Close control was possible by quenching to this hardness, then drawing back to Rc 44-46 as specified. Further tests showed that QUENCHOL 521 was equally superior for many other types of commercial heat-treating."

It will pay *you* to get the facts on the performance benefits of QUENCHOL 521. Contact your local Sinclair Representative or write, if you prefer, for the new booklet about QUENCHOL 521 to Sinclair Refining Company, Technical Service Division, 600 Fifth Avenue, New York 20, N. Y. *There's no obligation.*

SINCLAIR

CUTTING OILS and COOLANTS

It's Fast
It's Thorough
It's Economical

It's your Best Buy in Degreasing Agents!

Nialk® TRICHLORethylene

When you stack up all the advantages offered by Nialk TRICHLORethylene you'll understand why more and more companies are standardizing on it for metal parts degreasing.

Versatile—the ideal organic solvent for removing practically every kind of foreign matter—waxes, greases, oils, gums, tars—even chips. Leaves parts clean, warm, dry, ready for assembly, inspection or surface treatment.

Fast—Acts quickly, cleans and dries rapidly. Its low boiling point (86.6°-87.8°C, based on standard ASTM tests) permits vaporization at low steam temperatures.

Thorough—Low viscosity (0.58 centipoises at 20°C) and low surface tension (about 29 dynes per cm at 30°C) assure diffusion into pores and relatively inaccessible openings.

Economical—Stable and completely usable after distillation. Cuts power consumption . . . can be heated by gas, steam or electricity. Gives concentrated vapor at only 188°F. Specific heat is less than 1/4 that of water. Cuts vapor loss—high vapor density (4.5 times that of air) assures proper vapor level at all times.

Safe—Has neither flash point nor fire point; classed as nonflammable at room temperatures, only moderately flammable at higher temperatures (Underwriters' Laboratories rating 3).

Order by the drum, carload or tank car. Deliveries can be made promptly. A request on your letterhead will bring you a free copy of our Nialk TRICHLORethylene booklet.

NIAGARA ALKALI COMPANY

60 East 42nd Street
New York 17, New York

NIALK® Liquid Chlorine • NIALK Caustic Potash • NIALK Carbonate of Potash
NIALK Paradichlorobenzene • NIALK Caustic Soda • NIALK TRICHLORethylene
NIAGATHAL® (Tetrachloro Phthalic Anhydride)

Metal Progress

June 1955
Volume 67, No. 6

Heat Treating Aluminum Alloy Aircraft Parts

A Builder's Viewpoint

*By R. H. GASSNER**

Optimum properties are required in aluminum alloy parts used in modern aircraft. This dictates a necessity for close control over heat treating furnaces and quenching facilities.

WEIGHT-CONSCIOUS designers of the high-speed aircraft and missiles now on the drawing board are demanding that metals be utilized to the absolute limit of their capabilities. These demands must often be satisfied by the establishment of more stringent controls over manufacturing processes; hence, they are often reflected in the requirements for processing equipment. The purpose of this paper is to illustrate how metallurgical principles dictate the requirements of heat treating equipment for wrought aluminum alloys.

Aluminum Alloys

Solution heat treatment of aluminum alloys consists of two steps, (*a*) heating and soaking and (*b*) quenching. During the first step, the alloy is heated to the soaking temperature range and held there long enough to allow solution and diffusion of the alloying elements in the aluminum to form a homogeneous solid solution. During the second step, the material is quenched in water to retain that solid solution at room temperature.

Figure 1, a portion of the aluminum-copper equilibrium diagram, will be used to illustrate how solution heat treating conditions are chosen. Note first the eutectic point, with its two parameters – temperature (548° C. or 1018° F.) and composition (33% Cu, 67% Al). This point defines the composition of the lowest melting alloy of these two metals (the eutectic composition) and its melting point (the eutectic temperature). Note, second, the line *AB*; it defines the solu-

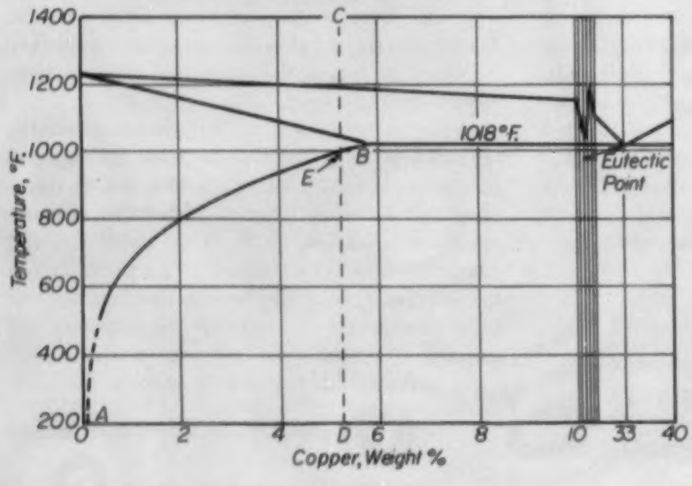
*Metallurgist, Douglas Aircraft Co., Inc., El Segundo, Calif.

Douglas DC-7, World's Fastest Piston-Powered Commercial Airplane

bility of copper in aluminum at various temperatures. The composition of a typical precipitation hardening binary alloy is indicated by the line *CD* representing 5.25% Cu.

The diagram shows that the soaking temperature range must not exceed the eutectic temperature because of the danger that segregated, copper-rich areas may melt. On the other hand, it must exceed the temperature defined by the intersection of lines *AB* and *CD* (temperature *E*) in order to dissolve all of the available copper. A small safety margin above the upper limit of the soaking range is necessary because the presence of eutectic melting results in *severe* losses in strength and ductility. The losses are caused by the as-cast structure of the resolidified molten metal; its properties resemble those of a casting. This condition is particularly hazardous because it often presents no external manifestations, and is not detectable by ordinary inspection methods.

Fig. 1 – Aluminum End of Aluminum-Copper Equilibrium Diagram



Likewise, the shallow slope of the solubility curve *AB* (that is, solubility decreases rapidly with small decreases in temperature) dictates the necessity for a small safety margin below the lower limit because, if maximum solution is not achieved, the degree of supersaturation after quenching will be lower than that required for optimum hardening. The soaking temperature range is sometimes further restricted by raising the lower limit as close to the upper limit as possible, commensurate with furnace capabilities, in order to take advantage of faster solution and diffusion rates.

The composition of the typical alloy, *CD*, is 5.25% Cu, 94.75% Al. Since the eutectic temperature is 1018° F. and the intersection of *CD* with *AB* is at 996° F., the soaking temperature range should be 999 to 1014° F. This 15° range allows a 4° safety margin on the high side to safeguard against eutectic melting, and a 3° cushion on the low side for increased solution and diffusion rates. Of course, a composition of higher strength could have been chosen, say 5.60% Cu, but its soaking temperature range would probably have been limited to 1016 to 1017° F. The selection of the 5.25% Cu alloy represents a compromise between strength and furnace capabilities.

Actually the equilibrium diagram and typical composition illustrated in Fig. 1 are similar to those of more complex, commercial alloys; their soaking temperature ranges are similarly narrow. For example, the eutectic temperature of 2024 (24 S) alloy is 932° F., and the upper limit of the soaking range is

930° F. The lower limit is 915° F., but it is dictated by temperature control limitations of present industrial furnaces. Cooperative tests performed by the West Coast airframe companies have shown that significantly higher strengths could be obtained from this material if the minimum soaking temperature were raised. (See Fig. 2.)

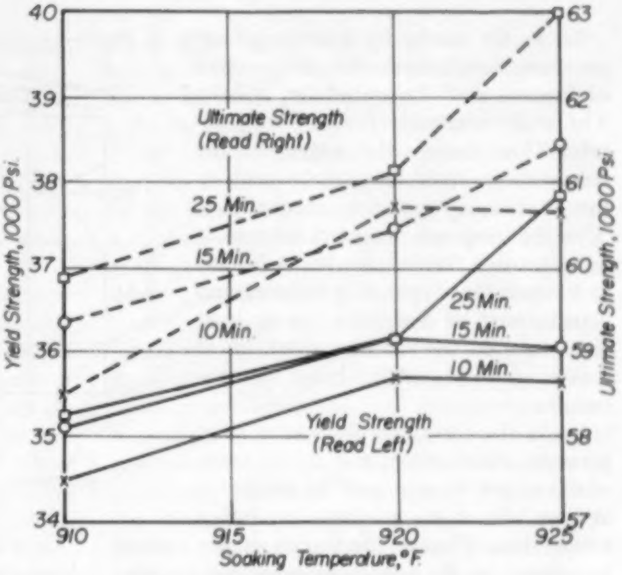


Fig. 2 – Strength Versus Soaking Temperature for Alloy 2024-T 4

The preceding information delineates the origins of the requirements for adequately instrumented furnaces which will maintain metal temperatures accurately, within a narrow range. A safety control instrument, set at the upper limit of the range and operating in conjunction with an alarm system or automatic cut-off, is additional insurance against eutectic melting.

Usually, temperature uniformity and control requirements are easily met by properly instrumented salt bath furnaces. Immersion electrode types are somewhat superior in uniformity, due to their inherent agitation; however, the thermal conductivity of the molten salts is sufficient to allow many gas-fired baths to operate successfully within very narrow temperature ranges. This advantage of salt baths is somewhat offset by their well-known lack of versatility when different soaking temperatures are used; heating or cooling the large mass of molten salt involves long waiting periods.

Waiting periods – Although air furnaces are more adaptable than salt baths when several different alloys are to be solution heat treated, they suffer from a similar, less easily recognized limitation – namely, when the operating temperature of an air furnace is changed, waiting periods are required after the control instrument *indicates* stability in order to allow the furnace walls to stabilize at the new temperature. If waiting periods are omitted, improper heat treatment may result because parts in the furnace will radiate heat to colder walls or absorb radiant heat from hotter walls. The effect of radiation on the control thermocouple, because of its small surface area, will be much less than on the parts; therefore the soaking cycle indicated by the control instrument will not reflect the actual metal temperature in the normal manner. The magnitude of this limitation is directly proportional to the efficiency of the furnace as an insulated chamber, but possibilities of such radiation effects should be recognized even in thin-walled furnaces. A test used by the West Coast airframe companies for establishing requisite waiting periods for rectangular air furnaces is described as follows:

1. *Test thermocouples,* radiation test thermocouples, potentiometer, and cold junction compensation shall have been calibrated, during the previous three months, to read temperature within 2° F. Radiation test thermocouples shall be peened into the center of a panel of 6061 (61 S). The panel shall be a 1-ft. square of the minimum gage into which the thermocouple can be peened, and shall be heated to 970 to 1010° F. in an air furnace and air cooled prior to use.*

2. *Number and Distribution* – Nine test thermocouples are to be located at eight corners and center of the working zone. If radiation test thermocouples are used, one radiation panel is required for each 5 ft. (linear), or fraction thereof, of each vertical furnace wall, located at the midheight of the working zone; these panels shall be symmetrically distributed, parallel to the walls, at the outer limit of the working zone.

Test Procedure is as follows:

1. A furnace stabilization survey shall be made for increasing and for decreasing temperatures.

*The air cooled 6061 (61 S) material is used for radiation panels because its dark surface readily absorbs radiant heat.

1a. In the survey by increasing temperature stabilization, the temperature of furnace shall be stable for at least 3 hr. at the minimum operating temperature. Then change the setting of the temperature controlling instrument to the maximum operating temperature. After the temperature control instrument indicates that the furnace has stabilized at the maximum operating temperature, corroborated by a straight line at least ¼ in. long on the recorder chart, insert a rack of work containing test thermocouples.

1b. In the survey by decreasing temperature stabilization, the temperature of the empty furnace shall be stable for at least 3 hr. at the maximum operating temperature. Change the setting of the control instrument to the minimum operating temperature to be used. Turn off the furnace heat and open the furnace doors, leaving the blowers on. When the temperature controlling instrument indicates that the furnace has reached 100° F. below minimum operating temperature, close the doors and soak until the controlling instrument indicates that the furnace has stabilized at or below the minimum operating temperature. Then turn on the furnace heat. After the temperature control instrument indicates that the furnace has stabilized at the minimum operating temperature, corroborated by a ¼-in. straight line on the recorder chart, insert a rack of work containing test thermocouples.

2. The temperature of all test and furnace thermocouples shall be recorded at 5-min. intervals (maximum) after placing them in the furnace. Readings shall be taken for 30 min. after all reach the temperature range being surveyed. Determine the minimum and maximum temperatures of recurrent temperature pattern of highest and lowest test thermocouples.

Another type of radiation problem is sometimes encountered when the heating source of an air furnace is in the walls. If the shielding between the heating elements and the working zone is inadequate, metal temperatures will exceed air temperatures. Significant radiation effects, amounting to metal-air temperature differentials in excess of 20° F., have been encountered when 0.064-in. gage stainless steel was used for shielding. These temperature differentials were not detectable after 0.5-in. asbestos board was added to the shield.

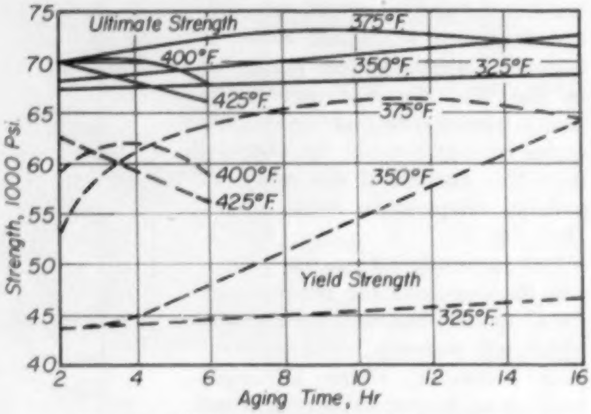


Fig. 3 – Effect of Aging at Various Temperatures on Strength of Al Alloy 2024-T 3

In addition to these temperature control problems peculiar to air furnaces, contamination of the atmosphere must be avoided. Sulphur dioxide and water vapor may cause high-temperature oxidation of the metal, usually manifested by surface blisters and subsurface voids or oxide. These act as stress concentrations and lower mechanical properties, especially fatigue life.

Quenching

The importance of close control over the quenching phase of solution heat treatment can be illustrated by Fig. 1. If the typical alloy were cooled infinitely slowly from the soaking temperature range, an intermetallic compound of copper and aluminum would precipitate and the amount of copper in solid solution would decrease with decreasing temperature along the line *AB*. Infinitely rapid cooling would follow line *CD* – that is, the composition of the solid solution would not change because the solute atoms would not have sufficient time to coalesce into particles of precipitate. The degree of supersaturation would be measured by the distance between *AB* and *CD* at the quench water temperature. Extremely rapid cooling rates, producing nearly maximum supersaturation, are necessary to assure that all lots of material will meet design requirements.

Rapid quenching is also necessary to attain maximum corrosion resistance in the high-strength wrought alloys. Slow quenching causes a drastic loss in corrosion resistance due to precipitation of a copper-aluminum compound at the grain boundaries, depleting the copper content in the metal adjacent to the boundaries.

That zone is anodic to (electrochemically more negative than) the remainder of the grain, and therefore is susceptible to corrosion; the depleted zone corrodes sacrificially at an accelerated rate. This is a very insidious type of corrosion because it proceeds internally and relatively little surface corrosion product is formed; hence, it could progress undetected to a point at which catastrophic failure would occur.

The cooling rate during transfer from furnace to quench is usually controlled by specification of maximum quench delay times. (The quench delay is measured from the time an air furnace door starts to open, or the time the first corner of a load emerges from a salt bath, until the last corner of the load is immersed in the water quench tank.) It is essential that immersion be completed before the metal cools below 775° F., and therefore maximum times vary from 5 sec. for gages under 0.017 in. to 15 sec. for gages over 0.090 in. After immersion, cooling rates are controlled by specifying maximum water temperatures before and after quenching.

A factor which must not be overlooked is the necessity for agitation of the water or the parts during quenching. This is dramatically illustrated by the susceptibility of 0.50-in. 2024-T 4 plate to intergranular corrosion when quenched in still water (3-sec. delay), and its freedom from such susceptibility when quenched with sufficient agitation to break up the insulating steam blanket which collects on the surface of the hot metal.

A relatively minor amount of hardening results from solution heat treatment; in the freshly quenched condition the material is almost as soft and ductile as in the annealed condition. The main purpose of solution heat treatment is to condition the alloy for subsequent age hardening treatments.

Hardening

Precipitation hardening or age hardening is responsible for the major portion of the hardening effect. It consists of precipitation of fine particles from the supersaturated solid solution, and occurs because of the alloy's tendency to progress toward a state of equilibrium – that is, toward the ratio of precipitate to solid solution indicated by the equilibrium diagram (Fig. 1). The amount of hardening is governed by the number and size of the precipitated particles which, in turn, is a function of temperature at the time of precipitation since the mobility of the atoms determines the number and size of the groups into which they coalesce. Hence, precipitation at elevated temperature produces higher hardnesses and strengths than room-temperature aging.

The hardening effect of the precipitate results from the strain in the solid solution crystal caused by the presence of the "foreign" particle. Up to a certain limit the larger the particles, the greater the strain; beyond that limiting size strain (and strength) decreases. Particle size then becomes so large that the number of particles formed is insufficient to "key" the optimum number of slip planes. Therefore the time-temperature conditions of precipitation heat treatments are carefully selected to produce a precipitate which gives the best combination of properties. The series of curves in Fig. 3 shows the effects of various aging times and temperatures on the mechanical properties of 2024-T 3 (24 S) alloy; the reasons behind the choice of a precipitation heat treatment consisting of 10 hr. at 375° F. are readily apparent.

Figure 3 also illustrates the necessity for temperature uniformity and control in aging furnaces similar to that required for solution heat treating furnaces. Problems of radiation and heat distribution are somewhat less critical, due to the lower temperatures, except in the few furnaces which are used for both precipitation and solution heat treating. In the latter event, the heat capacity needed for the high temperatures tends to produce detrimental radiation effects at the low temperatures. The long soaking times required for age hardening treatments have led to a trend toward large working zones. This partially offsets the advantage of controlling at lower operating temperatures, but control within specified limits is still easily possible.

In conclusion, it must be realized that the requirements for heat treating equipment are established by the design engineer when he specifies the material and its properties on his drawing. Thereafter, the fundamental metallurgical principles involved determine the heat treating conditions, and the allowable tolerances, necessary to meet his expectations. When development of more efficient equipment and more accurate controls allows the designer to increase his requirements (that is, allows increased strength-weight ratios), lighter, more efficient airplanes can be produced. Such advances have been responsible for maintaining the supremacy of the American aircraft industry.

An Alloy Manufacturer's Viewpoint

*By K. B. BAKER**

MANY of the important physical qualities of aluminum alloy and magnesium alloy parts are controllable in accordance with established physical principles. Among the factors affecting the final results, the necessity for proper thermal treatments cannot be overemphasized.

Generalization is unwise. Heat treatments vary according to the job at hand. Proper design and selection of the type of heating equipment and its auxiliaries obviously must follow an adequate study of the specific requirements. Otherwise unsatisfactory results may be expected.

Annealing – When necessary to anneal wrought aluminum alloys, the general principle is to heat as quickly as possible to the proper *metal* temperature for the product concerned and to avoid an unnecessarily long period of holding at that temperature. If the rate of heating is too slow, or if the control of the metal temperature is so inaccurate that it reaches a temperature considerably higher than required for recrystallization, an excessively large grain size will result in some aluminum alloy materials. If a heat treatable alloy is heated substantially in excess of prescribed annealing practice, "partial" heat treatment may result in the sense that the properties will be unstable and the product will gradually harden at room temperature. Hence the annealing equipment must be capable of raising the desired load size quickly to temperature and of controlling the actual metal temperature within accurate limits.

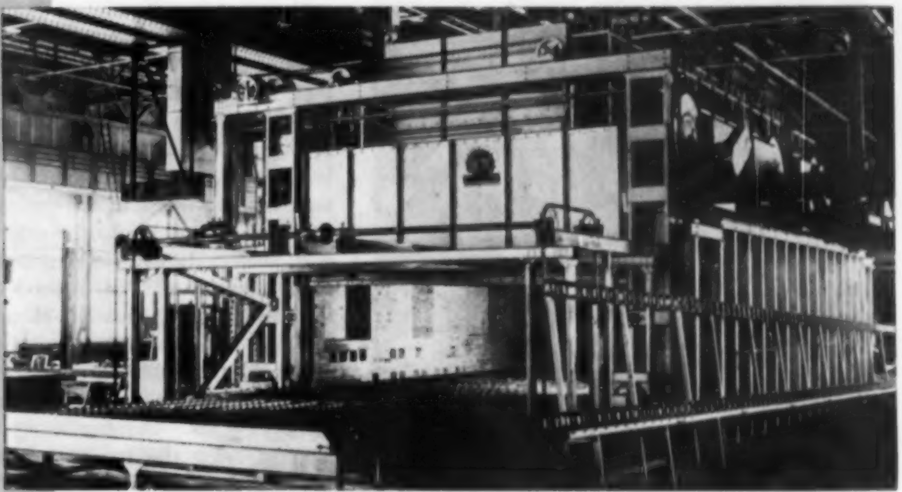
Solution heat treatment of wrought aluminum alloys is for the purpose of putting into solid solution the soluble alloying elements and to retain them in a supersaturated solid solution by quenching. When the hardening constituents are later precipitated from the supersaturated solid solution, full hardening occurs. Precipitation occurs either as a result of the unstable nature of the solid solution at room temperature (in some of the aluminum alloys), or by a precipitation heat treatment, more familiarly termed "artificial aging".

As is well known to those acquainted with phase diagrams of the aluminum alloys, certain phases begin to melt at temperatures well below those at which melting is obvious to the eye. Yet the maximum strength possible prescribes a solution heat treatment at maximum permissible temperatures. The heat treating furnace should therefore be capable of maintaining *the actual metal temperature* within plus or minus 10° F. of that specified. If this is exceeded, eutectic melting may occur. Once this happens, the mechanical properties are adversely affected; more often than not the product exhibits a characteristic type of blistering. These conditions cannot be corrected and the product must be scrapped. Correspondingly, if the temperature reached is too low, the minimum mechanical properties may not be developed, so proper reheat treatment will be required.

Equipment – All the foregoing emphasizes the importance of a furnace which is capable of raising the desired load *quickly* to an accurately controlled temperature, properly set for the alloy and product concerned. It does not suffice to have highly accurate temperature control equipment alone. Unsatisfactory results have often been obtained where the instruments show close control of the temperature, but this situation prevailed only in the vicinity of the point of control and the furnace design was such that widely varying metal temperatures existed elsewhere in the load. The point to be emphasized is that the actual metal temperatures throughout the load must be determined and proved to be within required limits.

Another feature of importance in the solution heat treatment of aluminum alloys concerns the arrangements for handling and quenching the load. Not all alloys and products require the most drastic quenching; in fact a slower quench, as in boiling water instead of cold water, is preferable for some. The requirements must be carefully established and the equipment organized accurately. When rapid quenching is necessary to obtain satisfactory mechanical properties and resistance to corrosion, facilities inadequate to provide rapid quenching can only lead to poor quality of product.

*Works Chief Metallurgist, Edgewater (N.J.) Works, Aluminum Co. of America.



Pusher-Type, Gas-Fired Furnace. Courtesy R-S Products Corp.

Furnaces for Heat Treating Aluminum and Magnesium

*By D. W. PETTIGREW**

Four major factors influence design of furnaces for heat treatment of aluminum and magnesium: Temperature control, heat input, material handling, and atmosphere requirements. Present high production rates have increased the importance of material handling.

ALUMINUM and magnesium alloys used in the aircraft industry have similar heat treating cycles. Both are solution heat treated, quenched or cooled to room temperature, and then age hardened at an intermediate temperature.

For maximum production rates during solution treating the material should be heated as rapidly as permissible. High-strength alloys require rapid cooling and are quenched in cold water, either by immersion or spraying. Where strength requirements are lower, quenching in hot water or air is often permitted. Some extrusion and forging alloys have acceptable mechanical properties when quenched as they rest in or leave the die. For precipitation heat treatment, the material must usually be heated for a long

*Sales Engineer, Swindell-Dressler Corp., Pittsburgh.

time at an intermediate temperature. However, certain alloys will harden at room temperature.

Major considerations influencing furnace design for heat treating aluminum and magnesium are temperature control, heat input, material handling, and atmosphere requirements.

Temperature control must be rapid and accurate because of the narrow ranges specified for heat treatment. For example, duralumin-type alloys are solution treated between 925 and 930° F. in order to get maximum properties. If their temperature were to exceed 932° F., they might be damaged beyond repair. If temperatures fall below the specified range, the necessary mechanical properties cannot be obtained.

Fortunately, instrument manufacturers can provide controls that meet the requirements when used with properly designed furnaces.

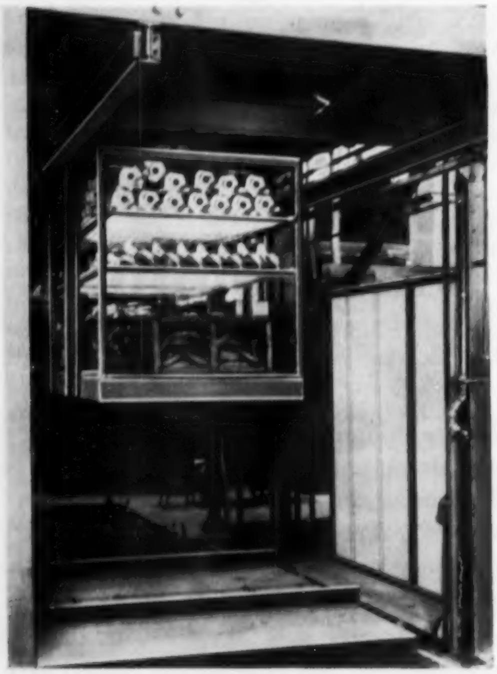
Heat Input – Aluminum was first heat treated in gas fired, open-burner furnaces, copies of those used in the steel industry. However, it was not long before blisters and a condition called "HTO", or high temperature oxidation, were associated with combustion products from the open burners. To avoid this difficulty, electric resistance heating was adopted generally.

Where natural gas has become available at low cost, electricity for heating becomes comparatively expensive. The method adopted by the furnace industry to use the cheaper fuel without damage from the combustion products is the radiant tube, wherein combustion is entirely within heat resistant alloy tubes which line the furnace walls. Combustion products are exhausted from the tubes and never touch the work in the furnace.

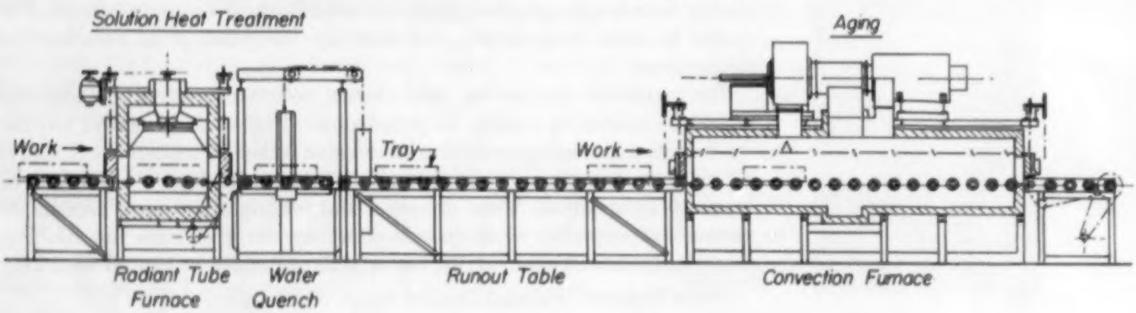
Except for some special applications, magnesium is heat treated in the same kind of furnaces used for aluminum.

Oil is not yet used widely for heating aluminum and magnesium. It is still too expensive compared to gas except in a few geographic areas. Combustion products are detrimental to metal surfaces, particularly from those oils which contain sulphur. Even the use of oil to heat radiant tubes is difficult because oil burns with such a short, hot flame. However, we may hear more about the use of oil in the future.

Material Handling – Fuel selection is important in determining production costs and is so considered by furnace builders. However, with present production requirements a furnace can



Rack Loaded With Aluminum Castings Is Raised Into Rectangular, Elevated Furnace for Solution Treatment. Floor plate covers quench tank. Courtesy W. S. Rockwell Co.



Semicontinuous Installation for Solution Treatment, Quenching and Aging Small Aluminum or Magnesium Parts Loaded in Trays. Courtesy Surface Combustion Corp.

be considered as an insulated box in which material is placed to be heated to a prescribed temperature; the method of getting the material into and out of the box (material handling) controls the operation.

The loading and unloading is accomplished with pushers, rollers, elevators, walking beams, cranes, chains or cars. These units started out as small accessories, but as the aircraft industry required larger and more intricate pieces, the material handling equipment became a major consideration in furnace design. The accompanying illustrations indicate some of the different methods used today, and their importance in furnace design.

Atmosphere Control – A fourth consideration is the possibility of using protective atmosphere. Furnace atmospheres and their generation were covered by the symposium held by the Industrial Heating Equipment Assoc. at the last Metal Congress in Chicago, and were published in *Metal Progress* in the November 1954 issue.

Protective atmospheres have not yet been considered necessary for aluminum. The required safeguards against contact between work and combustion products are sufficient to assure a satisfactory product.

With magnesium, on the other hand, solution heat treatment is usually conducted in a protective atmosphere containing sulphur. Usually SO_2 in minimum concentrations of 0.5%, formed by the heating of flowers of sulphur in the load chamber, is used. Early in the development of magnesium alloys, it was recognized that the presence of sulphur was necessary to reduce oxidation. When aluminum and magnesium alloys are being heat treated in the same plant, equipment must be duplicated, since a sulphur-bearing atmosphere damages aluminum beyond repair.

Design of heat treating furnaces with protective atmospheres, if and when required, will be similar to those developed for other metals. This will include an all-welded shell, tight door seals, and seals at bearings, burner ports, terminal openings, and the like. Most of these items, already developed, have been proven and make a gas-tight furnace. There should be no difficulty in adapting the present methods of sealing a furnace to the heat treatment of light metals.

Electrically Heated Elevator Furnace for Aluminum Extrusions and Tubing. Load is water quenched vertically in tank below furnace. Courtesy Swindell-Dressler Corp.

Salt Bath Furnaces for Aluminum

By *BERNARD P. PLANNER**

Salt baths offer many advantages for heat treatment of aluminum aircraft alloys, including high treating rates, close temperature control and freedom from atmosphere attack.

On the West Coast, as is generally known, is located more than 50% of all American airplane manufacturing. In the Los Angeles area, the airframe industry occupies a greater factory area than all other industries together. Aluminum alloys still constitute by far the major part of all their metallic construction materials (according to recent statistics, about 70%). The importance of aluminum alloys and the furnace equipment used in their processing is obvious.

Temperatures used in heat treating aluminum alloys range from 250 to 980° F.; thus, 250 to 375° F. is for precipitation hardening, 640 to 660° F. for strain relief, 750 to 800° F. for dead soft annealing and 850 to 980° F. for solution annealing. Almost all of this range can be handled by salt bath furnaces.

Solution anneal, aging and quenching are closely controlled. Process specifications are particularly stringent as to maximum physical properties as well as corrosion resistance. When, after years of research, a new alloy with a higher yield and tensile strength has been developed, we do not want to sacrifice any of this strength by the use of inferior heating or processing equipment.

The same maxim applies to corrosion resistance. When you visualize planes on the deck of a storm-tossed aircraft carrier, you see just about the worst atmospheric corrosive conditions imaginable.

Control of quenching rates is important because slow quenching can impair both strength and corrosion resistance of high-strength aluminum alloys. The temperature range requiring close attention is 550 to 750° F. In order to avoid difficulty the quenching rate through this range should exceed 800° F. per sec. With some alloys corrosion resistance is adversely affected before the mechanical properties suffer; with others, the reverse is true. A qualitative indication of the influence of quenching rate on 2024 (24 S) and 7075 (75 S) is shown in Fig. 1. If 2024 is not quenched fast enough to pass the nose of the "C-curve" in less than 5 sec., it becomes susceptible to cor-

*Chief Metallurgical Engineer, A. F. Holden Co., Los Angeles Plant.

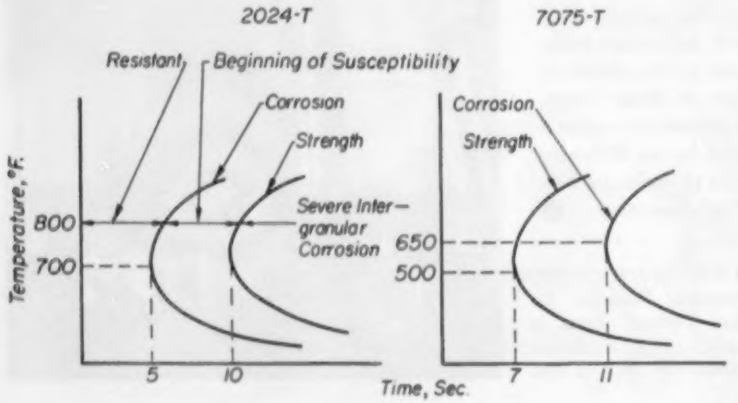


Fig. 1 – Influence of Quenching Rate on the Properties of Two High-Strength Aluminum Alloys

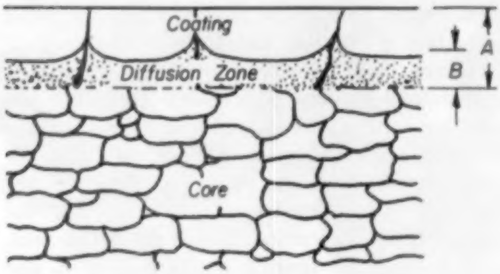


Fig. 2 — Diffusion in Alclad 2024 Alloy, Sketched at 100 Magnifications. A represents thickness of Alclad coating; B is average width of diffusion zone. The percentage of diffusion is calculated by B-A

rosion; if the time exceeds 10 sec., severe intergranular corrosion can develop and its strength will also be impaired. For 7075, mechanical properties are affected first by slow quenching rates; then corrosion resistance. The magnitude of the effect of quenching rate from solution treatment on the mechanical properties of age hardened 7075 is shown in the table at the bottom of the page.

To avoid the above difficulties, maximum quench delay time is usually specified in the processing procedure. This is measured from the time the work first breaks the surface of the salt bath until it is completely submerged in the water quench. It varies between 5 and 15 sec., depending on the alloy and the size and shape of the parts being treated.

Some distortion of parts can hardly be prevented in quenching. However, when relatively large and light-gage aluminum alloy parts are transferred rapidly into water, it has to be remembered that the parts are rather soft and even suffer distortion by the very impact against the water surface at the point of immersion.

Quenching from salt baths in the aircraft industry is usually done by hand, although some semi-automatic devices have been suggested. Results, therefore, depend on the manual skill of the operator. However, the principle of the arrested drop used in elevator-type air furnaces could be incorporated into a jack-rabbit type of conveyer. Fixtures as light in weight as possible are also recommended. Skillful quenching will go a long way toward reducing the straightening costs, which can account for as much as 80% of the total manufacturing cost of aircraft parts.

Among the many advantages of salt baths over air furnaces for solution annealing aluminum alloys are: faster heating rates; shorter heat treating cycles; greater production per cubic foot of furnace space; closer temperature control; and freedom from high-temperature atmospheric attack. In molten salt, heat is transferred to the work almost entirely by conduction at a rate five to six times the rate of heat transfer in air by convection. This not only decreases the time at elevated temperature but as a secondary effect prevents loss of corrosion resistance — for the following reason:

High-strength aluminum alloys have poor corrosion resistance. Therefore, they are nearly always clad with pure aluminum, as visualized in Fig. 2. During the solution anneal, some diffusion occurs, mainly of copper from the core into the copper-free cladding. Full resistance to corrosion is maintained only in the portion of the cladding where diffusion has not taken place. Diffusion is proportional to the time the part is held at solution annealing temperature. When large, unevenly distributed loads are to be handled, the much faster heating in salt baths causes less diffusion from the core into the cladding and a better product. A minor advantage is the reduction of grain growth in plain aluminum by faster heating rates.

Effect of Quenching Rate on Tensile Properties of 7075-T*
(Data from W. L. Fink and L. A. Willey)

Quenching Medium	Quench Rate†	Tensile, Psi.	Yield, Psi.	Elong. in 2 In.
Water at 70° F.	$\geqq$ 2,500	83,925	72,925	12.8%
Wood's metal at 170° F.	$\geqq$ 1,900	84,075	72,500	12.7
Light oil (39) at 70° F.‡	$\geqq$ 1,600	83,950	72,975	12.8
Medium oil (126) at 70° F.‡	275	83,200	71,425	13.0
Heavy oil (7900) at 85° F.‡	128	81,200	68,900	13.0
Alcohol at 70° F.	98	81,700	68,375	13.0
Boiling water	42	77,975	63,625	12.9
Air blast	13	65,375	43,750	13.0
Still air	4	53,275	26,450	15.3

*0.064-in. (14-g.) "as rolled" sheet, heat treated 20 min. at 870 to 880° F. Specimen cut transverse to direction of rolling. T Temper — Specimens aged, after 4 days at room temperature, for 24 hr. at 250° F. Results are average of four tests.

†Rate of cooling through the range 750 to 550° F. in °F. per sec. Average of two tests.

‡Oil mechanically agitated during quenching operation. Values in parentheses are viscosities in Saybolt Seconds Universal at 100° F.

Fig. 3 – Empty Salt Bath Furnace, Showing Design and Location of Electrodes. (A. F. Holden Co.)

The five to six-fold increase in heating rate allows a correspondingly larger production capacity per cubic foot of furnace working space. Parts of suitable shape can also be much more closely stacked in a salt bath furnace than in an air furnace wherein free passage of sufficient air has to be allowed. I believe the production capacity of a salt bath furnace of the same size sometimes is 10 to 12 times as great as in an air furnace. For example, a salt bath furnace with a working space only 36 in. long by 28 in. wide by 40 in. deep, can solution anneal 450 tubular aluminum alloy parts with 2.75 in. diameter by 0.070 in. wall thickness, 30 in. long, equal to 1150 lb. of aluminum per hour or 150,000 parts per month in a two-shift operation.

Design of Salt Bath Furnace

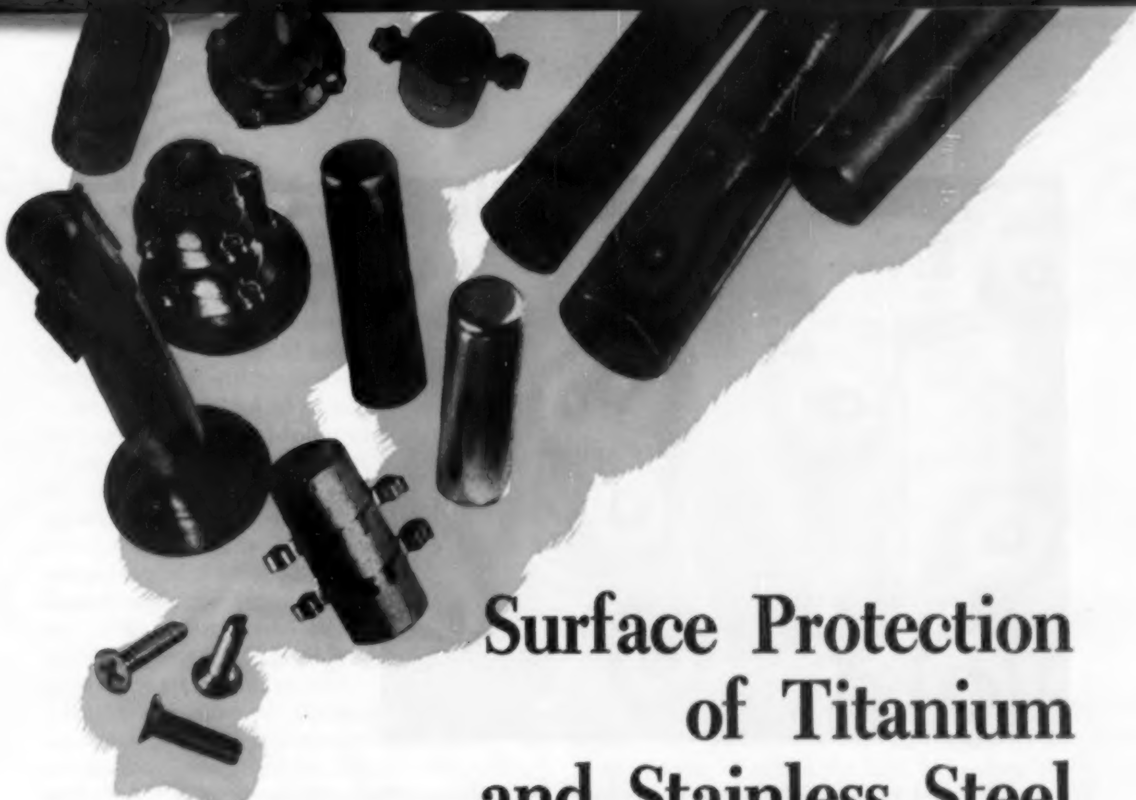
A typical salt bath, the A. F. Holden multiple electrode furnace, is shown in Fig. 3. It consists essentially of the inner steel pot, the outer shell and the electrode arrangement. The pot will be, of course, filled with molten salt. Heat energy is created (electricity is transformed into calorific energy) by the resistance of the salt to the current passing between the electrodes. The molten salt acts both as a protective blanket for the work and as a heat generation and transfer medium.

Dimensions and spacing of the electrodes are determined by the size of the bath, the salt mixture used, and the location of the work in the furnace. Minimum spacing is not less than 3 in. This permits heating a sufficient volume of salt between the electrodes without exceeding the temperature of decomposition of the nitrate salts.

Regarding the spacing of the electrodes and their influence on the maintenance of accurate temperature, I would like to add the following: Close temperature tolerances can be maintained in salt baths regardless of whether "Cal-Rod" immersion heaters, electrodes or gas-fired immersion heaters are used, provided enough calorific energy is furnished and the heating elements are properly distributed throughout the bath. The high rate of heat transfer and natural heat convection insure an even temperature distribution. Temperature tolerances of $\pm 5^{\circ}$ F. or better are unnecessary when heat treating steels. Therefore, the so-called electromagnetic stirring action of current on the salt, is, in my opinion, unnecessary; it erodes the electrodes, increases heat losses and oxidation of the molten salt bath – the very thing we use additives to prevent. (Oxidized salt pits the parts treated.)

When heat treating aluminum, eutectic sodium and potassium nitrate mixtures would be preferred because of their low melting point. Also, the fused salt combinations are more stable than granular mixtures. Any moisture is boiled out of this product during fusion, and the salts remain dry when properly packaged and stored in metal containers. In humid surroundings, salts that are not packaged absorb as much as 5% water. When stored in metal drums, the maximum moisture content of the salts will not exceed 0.25%.

There is just one more precaution: Care has to be taken to prevent a molten sodium nitrate bath from becoming alkaline – that is, from containing more than 0.03% free alkali expressed as Na_2O. On prolonged immersion in a bath containing free alkali above 0.10%, stains consisting of sodium aluminate are formed. Control of free alkali is, therefore, essential. Conditions which tend to accelerate decomposition of the salt and increase the free alkali must be avoided. Such conditions are created by incidental oil, grease or other contaminants from the work, and by overheating. Rectification of alkaline baths is done by either bubbling carbon dioxide through the bath periodically or by adding small quantities of sodium dichromate.



Surface Protection of Titanium and Stainless Steel During Heat Treatment

*By HORACE DREVER**

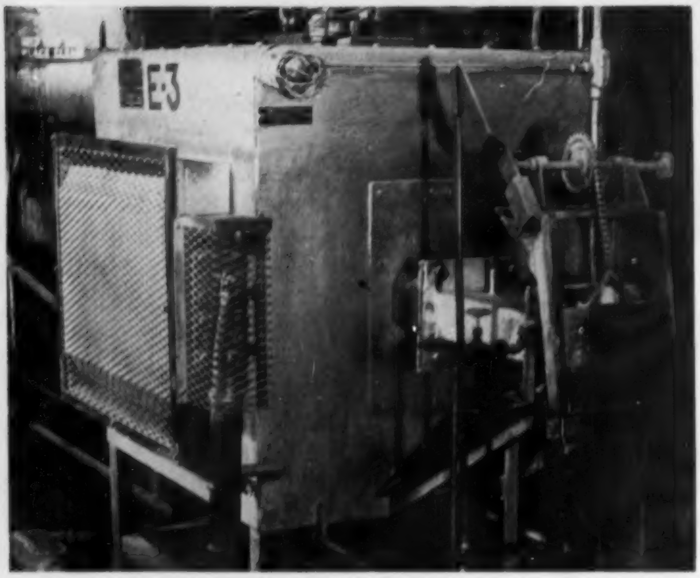
Vacuum furnaces have proved successful in preventing embrittlement of titanium during annealing. Extremely dry hydrogen is being used successfully in both bright hardening and bright annealing of stainless steels.

THE HEAT TREATMENT of titanium carries with it problems about equal in difficulty to those of producing the ingot from the ore. Since it is so reactive to most gases at elevated temperatures, atmospheres containing nitrogen and hydrogen are not "protective", and thus none of the standard types of atmosphere generators can be used. Since titanium is also reactive to oxygen, open firing is also unsatisfactory except for very large sections—ingots, perhaps.

This leaves only inert gases as a possibility for atmosphere protection. But this also brings problems. The gas—usually argon which must be thoroughly purified—is very expensive. In addition, it is very difficult to prevent slight infiltration of air into the heated chamber.

Since atmospheres are generally unsatisfactory, the only thing left to do is to use no atmosphere. Indeed, a vacuum of 10 microns or less is found to be most successful for avoiding embrittlement during heat treatment. It is only logical that a metal which must be *produced* in a vacuum should be subsequently *treated* in vacuum during later operations in order to preserve the qualities of the original ingot metal. While it

*President, Drever Co., Bethayres, Pa.



Simple Pusher-Type Batch Furnace Used for Bright Annealing Small Stainless Parts

is possible and entirely satisfactory to produce annealed material in heavier sections by conventional methods, even these are improved by the use of vacuum annealing. Fine ductile tubing, wire and thin sheet cannot be produced by using conventional annealing procedure, since the embrittling effect of the intermediate anneals is additive.

Vacuum processing of metals is rapidly becoming important in the titanium industry. It results in a stronger and more ductile product not only by preventing contamination from gases during the heating operation, but by removing gases already in solution in the metal. The gases in the metal, in equilibrium with the normal ambient atmosphere, diffuse outward into the vacuum (region of zero pressure). Such diffusion is impossible in conventional heat treating procedures at atmospheric pressure.

Vacuum equipment will be new to most production men and there are some essential techniques, easily learned, in its operation. The equipment now available is rugged and reliable, and in cost is usually less than atmosphere generation equipment would be for furnaces of the same capacity. In addition there is no danger of poisonous or explosive gases.

Any group which wishes to be successful in bringing out the best properties of titanium, had best put aside the worries and problems of embrittlement and look to this new and easily learned technique for the solution.

Stainless Steel – Applications of chromium-nickel alloys have grown tremendously with new and greater demands by engineers, not only because of better resistance to corrosion and high-temperature oxidation but also because of higher mechanical properties. Unfortunately, these alloys are difficult to heat treat without coloration. The chromium oxides are very refractory; to remove them requires long and expensive cleaning operations such as pickling in strong acids, sand-blasting or salt descaling. Such methods give a clean surface dull gray in color. If a bright finish is desired, additional costly mechanical operations such as machining, grinding or polishing are required.

Fortunately, we now have methods and furnace equipment for bright hardening and annealing all types of stainless steel alloys, so as to eliminate subsequent cleaning operations.

Bright Hardening—To develop their best properties, martensitic alloys of the straight chromium types, containing various percentages of carbon, must be hardened from somewhere between 1700 and 1950° F. by rapidly cooling in oil or air. Typical of these alloys are A.I.S.I. Types 410, 416, 420, 431, 440, each containing more than 11.5 but less than 18% chromium, various other alloying constituents and varying percentages of carbon, rising with the chromium content and depending on the hardness desired in the final part.

While oil hardening may give slightly higher

hardness on larger sections, air cooling is a recommended and safer practice in handling irregular, odd-shaped sections with sharp corners where distortion or cracking would be likely to occur. Since these alloys air-harden, bright heat treating is possible; the furnace design permits the parts to be quenched in cooled, controlled-atmosphere gas without traces of oxidation almost certain if quenched in oil. Parts shown on this page develop full hardness in sections up to 1.25 in. diameter. They are clean, free from oxide and are ready for the next operation, if one is required, or for final assembly. Screws require a certain degree of hardness to prevent stripping and galling of the threads; they come from the furnace ready for inspection and packing, thus eliminating what was formerly an expensive cleaning operation. Typical hardness values are given in the table on p. 90.

Bright Annealing of Stainless—Considerably more stainless steel is annealed than hardened, and the requirements in this direction are necessarily far more comprehensive and cover a much wider range of sizes, shapes and output. The most common alloys contain 6 to 22% of nickel and 16 to 26% chromium, with or without titanium, molybdenum, or columbium. These austenitic stainless steels cannot be hardened by heat treatment, but do develop hardness through cold working. Thus, annealing is the principal heat treatment to produce maximum softness and ductility and remove stresses from cold working. Annealing at proper time and temperature also dissolves any chromium carbides that may have precipitated at the grain boundaries during hot working or welding operations. To redissolve such carbides it is necessary to heat the metal above 1650° F., soak long enough to be sure the carbides are redissolved, and then cool *rapidly* to hold them in solution.

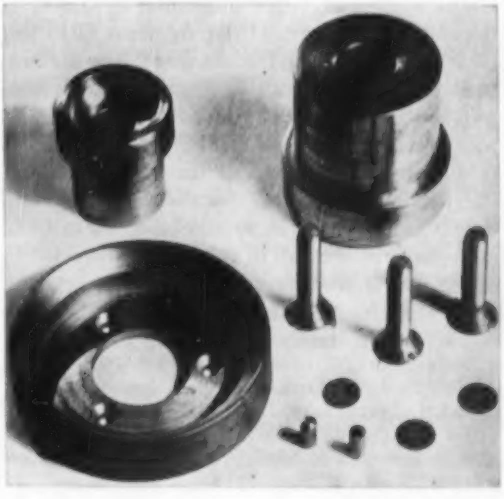
Normally, the purpose of bright annealing is for softening only. (If the parts have been previously exposed to the precipitation range by hot working, welding, or heating, the surface will be already oxidized at least in the heated portions and the scale would have to be removed by appropriate methods.) Carbide precipitation is of concern; it must be prevented by rapid cooling. Water is a good coolant. Air is all right if the parts are of thin metal. Quenching in chilled atmosphere is done in the identical fashion used to bright harden the martensitic grades of stainless.

Austenitic materials which have not been stabilized—that is, contain no titanium or columbium—and do not have a higher carbon content than 0.08%, can usually be quenched in air or furnace atmosphere in sections up to 0.250 in. In bright annealing, the design and effectiveness of the cooling chamber is the determining factor, limiting the size of the part being treated without endangering it to carbide precipitation. Certain grades, such as high-alloy Type 310, should always be water quenched because carbides will precipitate even on rapid air cooling.

The most widely used austenitic alloy is 18-8, available in rods, bars, wire, sheet, strip, tubing and many other shapes. It is made up from these forms into a wide variety of articles. A few "run of the mine" parts are shown on p. 87, just as they come from the bright annealing furnace; they will not require any cleaning operations whatever. As in any mirror-bright surface they are hard to photograph—either they reflect the light source directly into the camera and gleam at such spots, or reflect the light away from the lens and appear dark.

The technique of bright annealing parts of this nature has been so far advanced that material with a mirror-like luster can be processed and retain and even slightly enhance this luster! Some of the parts are readily recognizable as to final use but others in the photograph include radio tube components, television and radio parts, and barrels for pen caps and lipstick containers. It is particularly interesting to note the perfect cleanliness of the *inside* of the pen caps which are tubular parts with one end closed. A

Bright Hardened Stainless Steel Parts



Typical Hardness Readings for Bright Hardened Stainless Parts

Part	Material	Section Thickness, Max.	Hardness, Rockwell		Laboratory Hardness*
			Specified	Obtained	
Cup plate	440 A	1/4 in.	C-57-60	C-58-60	C-55-58
Small gears	416	1/32	40-42	40-41	39-43
Bolt	420	7/16	52-56	53-56	53-56
Bearing pin	416	1 1/4	35-43	40-43	39-43
1 5/16-in. bearing race	416	9/16	35-43	38-40	39-43
15/16-in. bearing race	410	1/4	35-43	38-40	39-43
Small nozzles	440 A	3/16	53-58	54-58	55-58

*On 1-in. diameter bar, oil quenched.

piece such as this represents an almost impossible object to pickle so the whole interior surface is cleaned of all oxides; bright annealing eliminates this troublesome and expensive operation. If any oxide were left in the part, it would cause a great amount of trouble in the subsequent drawing operations as well as on the finished part.

The furnace illustrated on p. 88 is one of the usual forms of equipment for bright annealing and bright hardening parts. It is a simple pusher-type batch furnace with a deep charging throat, an alloy muffle forming the heating chamber, and a cooling chamber, all mechanically fastened together and filled at all times with an atmosphere of dissociated ammonia or pure hydrogen. Material is fed into one end, pushed into the heating chamber and, upon completion of the heating cycle, is pushed into the cooling chamber. When parts have cooled to 300° F. or less, they are removed from the cooling chamber. The muffle in this type of furnace may be heated with electricity or gas.

The success of bright hardening or annealing depends on rather rigid requirements as to furnace construction and atmosphere. The furnace heating chamber must be constructed of materials which are not reduced by hydrogen at temperatures of 2000° F. and higher, and the atmosphere used throughout the furnace (charging, heating and cooling chambers) must contain *no* oxygen, either free or combined as in CO_2, nor water vapor down to a dew point of —40° F. or below. If these requirements are met and if the charging and discharging entrances of the furnace are carefully designed so breathing of air is reduced to a minimum, then the average furnace operator can bright harden or bright anneal.

The requirement that the heating chamber must not be reducible by hydrogen necessarily eliminates all common refractories from consideration as a lining material and conversely implies that an alloy muffle must be used. Alloys high in nickel are the most reliable for muffle construction; materials such as Nichrome and Inconel give excellent results.

The atmosphere is, of course, of the utmost importance and either pure hydrogen or dissociated ammonia is used. Dissociated ammonia is delivered from the ammonia cracker as 75% hydrogen, 25% nitrogen by volume. The dew point is −65° F. or lower, and only a very small trace of uncracked ammonia remains. Dissociated ammonia is favored because it requires no purification or drying and it is more economical than cylinder hydrogen.* In certain applications, the very slight nitriding effect of cracked ammonia prohibits its use; pure hydrogen must then be used. Since cylinder hydrogen is too wet, it must first be deoxidized and then dried before going to the furnace. This requires separate equipment consisting of a catalyst furnace wherein small amounts of oxygen in the gas are converted to water vapor, followed by drier towers to remove water vapor down to the necessary dew point.

Since any foreign matter on the surface of the material to be treated would not only contaminate the heating muffle but would discolor and oxidize the part, it is also important that all such matter be removed before entering the furnace. Cleaning is best done in vapor-type solvents rather than the alkaline types which may leave a deposit on the work.

With properly designed and constructed furnaces and the correct atmospheres, bright hardening and bright annealing are now being done on a production basis on a large variety of stainless parts. Not too many years ago this operation was not considered feasible and there were many claims that stainless steels could not be properly treated in this fashion. This, of course, is now disproved by the excellent results which are obtained in all types of furnaces designed for this purpose.

*Editor's Footnote – In discussion it was mentioned that there is evidence that type 431 stainless (16 Cr, 2 Ni, 0.20 max. C) loses some ductility after austenitizing in "dry" hydrogen, unless the dew point is below −90°F.

Controlled-Atmosphere Furnaces

*By CARL L. IPSEN**

A survey of the prepresentative types of controlled-atmosphere furnaces, their advantages and major fields of application. Extracts from a paper read before the Western Metal Congress and Exposition.

THE ADVANTAGES of controlled atmospheres for heat treatment have led to the development of atmosphere furnaces for practically all heat treating operations. The trend is to replace older types of furnaces and the proposals of such replacements rate high in well-considered modernization programs. What follows is a brief description of representative types of these newer furnaces.

Batch Furnaces

Box Furnaces – The most widely used of any type are the box furnaces; they can be found in almost every plant doing heat treating. Until recent years these furnaces, as their name signifies, were simple boxes with a door at one end and an insulated heating chamber with a hearth for receiving the work. Some were provided with protective atmospheres, but they all shared one feature: The operator removed the work manually and transferred it through air to the quench tank. A certain amount of discoloration and scaling was inevitable.

The modern furnaces have a hooded quench tank built integrally with the furnace, and automatic means of charging the work into the furnace on racks or trays and subsequently transferring it from the furnace into the quench tank. This entire operation is performed in a protective atmosphere to prevent exposure of the hot metal to oxidizing or decarburizing atmospheres so that the heat treated work retains its original machined luster. The furnaces are often provided with fans to circulate the hot atmosphere, speed up the heating rate and uniformly subject all parts undergoing heat treatment to the atmosphere. Bright hardening, carbon restoration, carburizing and carbo-nitriding are the treatments commonly performed.

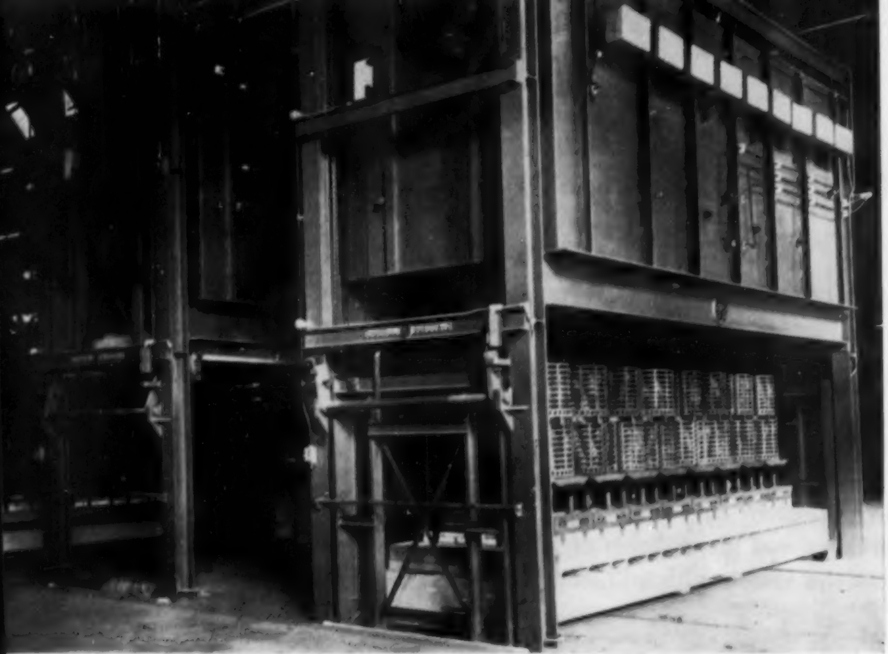
Some "box" furnaces are arranged for charging at one end and discharging at the opposite end. In such a furnace the discharge chamber may have a fan for rapidly recirculating a cooling gas. It would be used for heat treating so-called air quenching steels and for annealing and tempering. Enclosed quench tanks can also be provided in the straight through-type of box furnace.

In many designs all operations are automatic after the charge is placed on the charging platform. The various sequences and progressions are program controlled by an electric timer and limit switches. Means are provided for rapidly recirculating the quenching medium and automatically maintaining its proper temperature; this may call for either cooling or, as in martempering, heating.

Bright annealing and brazing of stainless steels introduce new problems. Chromium oxides can be reduced only in atmospheres of unusually high purity. Purified hydrogen or dissociated ammonia atmospheres are most commonly used and these gases must be maintained in the furnace at very low dew point, sometimes on long cycle work as low as -70° F.

Furnaces for bright annealing and brazing of stainless steels must be tightly sealed from air infiltration and use metal retorts of heat resisting

*Executive Vice-President, Industrial Heating Equipment Assoc., Washington, D. C.



Elevator Type (Two-Part) for Annealing Malleable Iron Castings

alloys to shield the protective atmosphere from contamination by the brick lining of the furnace. Tightly sealed purging vestibules are required at the charge and discharge ends. The fact that the copper brazing of stainless steel, which requires the elimination of all surface oxides, is a practical production operation in this type of furnace illustrates the success of maintaining very high purity atmospheres in furnaces operating at high temperatures.

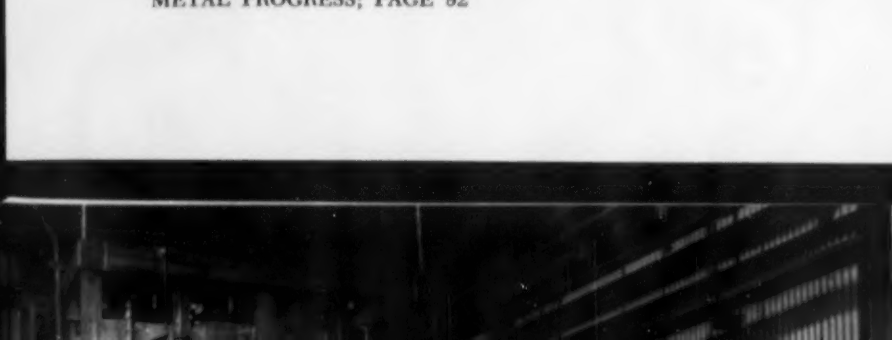
Elevator Furnaces – The photograph above illustrates a type of furnace in which the charge – malleable iron castings in this instance – provides its own atmosphere. A slight amount of carbon diffusing through the surfaces of the castings combines with the air in the furnace to create an atmosphere that is almost wholly CO and N. This is maintained throughout the cycle and only a negligible loss in carbon and scaling occurs. These furnaces are usually operated in pairs, one for high temperature and the other for the low temperature or the graphite precipitation part of the cycle.

Bell-Type – Cover or bell-type furnaces are also used in a similar manner. They have extensive application for the annealing of steel sheet and tin plate strip, and for annealing aluminum strip. These furnaces may contain either single or multiple stacks; the illustration at the top of the opposite page shows a single-stack bell type heated by gas-fired radiant tubes. An inner cover with its lower edge embedded in a sand seal in the base of the furnace effectively shields the charge from outside atmospheres during the heating and cooling cycles and confines the prepared atmosphere to a space where it can protect the work.

A fan placed in the furnace base rapidly recirculates the gas around the coils to speed the heating and to equalize the temperatures throughout the stack of coils. Heating time is further decreased by placing deflectors between the coils in a stack to deflect part of the recirculating gas through a desired path.

In the multiple-stack bell furnace, a number of inner hoods similar to the ones used in the single-stack furnace are enclosed in a single rectangular cover. A fan is provided in the base of each inner cover. The cover or bell is removed from both types of furnaces and transferred to another base when the charge reaches temperature. The inner covers remain in place holding the protective atmosphere until the charge cools to a temperature at which it will not discolor when exposed to the air.

The older mill practice for "correcting" surfaces of high-carbon bar stock which has been decarburized during hot rolling is to remove the decarburized surface by grinding or machining. However, one of the large eastern mills now restores such lost carbon during the anneal, spheroidization, or normalizing treatment in furnaces like the one shown on p. 94. In this photograph the charge is shown on the furnace car. The bell-type furnace in the background is raised and the car is pushed directly under it. The furnace is then lowered into an air-tight sand seal around the edges. Controlled atmos-



pheres with the proper carbon potential are then introduced to restore the depleted carbon on the surface of the bars.

Continuous Furnaces

Mesh Belt Furnaces – These have found widespread application for the bright annealing, brazing and sintering of small parts. A woven wire belt of high-temperature alloy moves over large pulleys at either end and carries the work through the heating and cooling chambers. Satisfactory operation is obtained at temperatures up to 2100° F. Flame curtains, asbestos curtains, and other means are provided to reduce infiltration of air through the open ends; even so, fairly large quantities of atmosphere gas are needed to maintain reducing conditions. Ease of operation and the high quality of bright parts delivered by the mesh belt furnace have led to its popularity.

To obtain an uncontaminated controlled atmosphere within the furnace, as for the bright annealing of stainless steel, construction must be modified. Inclined vestibules at the charge and discharge ends confine the lightweight gas, hydrogen or dissociated ammonia, to the elevated chambers for heating and cooling. Such a design also has the advantage of greatly reducing the consumption of controlled atmosphere.

Another kind of continuous furnace for bright hardening of small parts is the shaker or reciprocating hearth furnace. Oscillation imparted to the movable hearth advances parts placed on it at a controlled rate through the furnace; finally they drop through a sealed chute into the quench tank. With the furnace tightly sealed by the quenching medium at one end, atmospheres with a controlled carbon potential can be applied,

Single-Stack Bell Furnace for Heat Treating Coils of Strip

Roller-Hearth Furnace for Bright Annealing of Alloy Steel Tubes

Car-Bottom Furnace for Annealing and Carbon Restoration of Bar Stock

and parts are delivered with bright, uniformly hardened surfaces.

Automatic feeding and discharge conveyers from the quench tank minimize manual labor.

Pusher-type – Material placed on alloy trays or in alloy containers and pushed through a furnace on skids or roller rails is another widely used method of conveying material through a continuous furnace. Hydraulic or mechanical pushers advance the containers through the furnace on a pre-set time cycle, interlocked with a door-operating mechanism.

The pusher furnace with atmosphere control, which is used extensively for annealing gray iron and malleable iron castings, has greatly reduced the time of heat treatment. Many of these furnaces are now operating on cycles of 20 hr. and less, a sharp contrast with the 160 to 200 hr. required by the older batch or pack furnaces. An exothermic gas is commonly used.

Roller-Hearth – With this type the work is conveyed through the heating and cooling chambers on rolls whose shafts extend through the furnace walls and rotate in external bearings. The projecting ends of the rolls, which are usually driven through sprocket and chain, rotate on external bearings sealed to prevent leakage of controlled atmospheres.

Parts long enough to span the distance between rolls can be conveyed directly on the rolls (that is, without trays or carriers) such as the alloy steel tubing being bright annealed shown on p. 93. Output of this unit is 3000 lb. per hr. Other uses of roller-hearth furnaces include annealing of steel parts, gray iron and malleable castings, normalizing, sintering, cycle annealing and hardening of high-carbon steel parts.

Rotary furnaces are convenient for parts that must be removed from the furnace for fixture quenching or hot working. Automotive parts for instance, may be charged through one door, carried around on doughnut-shaped hearth through the heating chamber, and removed by hand through a door near the charging door and pressure quenched to minimize distortion. One man can handle both the charging and the quenching. Some makers use the same door both for charging and for discharging. One of the advantages of the rotary furnace is that the entire furnace lining, including the rotating hearth, can be of refractories and thus is not subject to the temperature limitations imposed on alloy parts.

Furnaces for Strip – The continuous annealing of strip, a process of rather recent origin, has demonstrated many advantages over batch annealing for many products. Heating cycles are exceedingly short and every part of the strip goes through the same time-temperature cycle.

One of the largest furnaces of this kind is 103 ft. long, 20 ft. wide and 63 ft. high (described in *Metal Progress*, February 1952, p. 62). It anneals tin plate strip at the rate of 1000 ft. per min., or 30 tons per hr. The heating chamber, heated by gas fired radiant tubes, provides six passes of the

a gas and the computed flame temperature with no excess air.

Figure 1 shows the speed of burning of various

cal properties of the reacting gases. Under actual operating conditions, they will be lower, since the theoretical temperature does not take into

strip, or about 325 ft. This is followed by an electrically heated holding chamber of six passes, then a retarded cooling chamber which cools the strip from 1350 to 1200° F. in 6 sec. and finally through 20 individually water-jacketed cooling chambers that cool the strip finally to 200° F. The controlled atmosphere used in the furnace and cooling chambers maintains the bright, cold rolled finish of the strip.

Similar furnaces are used for annealing strip preparatory to galvanizing. In these the strip is cooled only to the galvanizing temperature and is drawn directly into the zinc bath from a furnace duct with its discharge end submerged in the zinc. The cleansing action of the controlled atmosphere in the furnace provides bare metal of a texture which is an ideal base for the zinc, and the coatings are far more tenacious than those obtained by former galvanizing methods – in fact, galvanized sheet produced by this method can withstand severe deep drawing.

Controlled-atmosphere furnaces have been essential to the increase of production and the lowering of costs, and have even helped to create a wide variety of new products. Because advancements in furnace design are constantly bringing new benefits, cutting costs and offering new processes, controlled-atmosphere furnaces should merit a high place in every plant modernization program.

Gas Combustion Equipment

*By A. D. WILCOX**

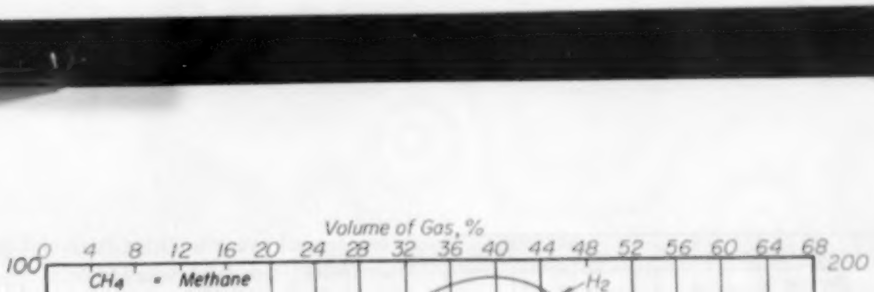
The combustible properties of gases depend on the constituents in a gas and on the flame temperature; the commonly used combustion systems and their qualifications are described.

THE GROWTH of the metal industry during the past decade has been paralleled by the use of gas in industrial heating applications. This growth in the use of industrial gas clearly indicates that people affiliated with metalworking should have an understanding of the elements of gas combustion and the equipment that is available.

To keep within limited space, this report on a broad subject will be confined to two parts – first, the important properties of commercial gases that affect combustion, and second, a description of the basic combustion systems being used in industry.

Tables I and II list the compositions of 26 commercial gases most widely used in industry, and the products of their combustion. Mixed or blended gases are also used. All of the data in Tables I and II have a bearing on the use of a particular gas. However, because this report will be confined to the broad scope of gas combustion, attention will be directed to the two listings that concern the combustible properties of the gas – the chemical constituents of

*Vice-President, Combustion Sales, Eclipse Fuel Engineering Co., Rockford, Ill.



a gas and the computed flame temperature with no excess air.

Figure 1 shows the speed of burning of various gases. The extremes encountered in industry are hydrogen, which is the fastest burning (190 in. per sec.), and methane, the slowest burning commercial gas (22 in. per sec.). Mixtures of gases with the slower burning rates can be used in delayed combustion applications, such as luminous flame, and will have a greater turndown rate (operation below the maximum thermal output of a burner and gas system). On account of their slower burning rate, better retention (ability of flame to stay at the part) or ignition qualities must be incorporated in the burner design. On the other hand, mixtures of fast-burning gases are not as adaptable to delayed combustion applications and are more susceptible to backfire. The faster burning gas needs less burner retention.

Flame temperature must be taken into account when considering operating temperatures of a particular application, and also in burner design. The temperatures listed in the last column of Table II are theoretical—that is to say, computed from thermal and thermo-chemical properties of the reacting gases. Under actual operating conditions, they will be lower, since the theoretical temperature does not take into account the heat losses from the flame.

Another property that should be considered is the limit of inflammability of a gas, as shown in Fig. 2. It will be noted that hydrogen has a lower limit of 4% by volume and an upper limit of 74%. Methane has a range of 5 to 15%. The importance of this property is two-fold: (*a*) It determines the safety of the air-gas mixture and (*b*) it determines the minimum and maximum limits of burning when air is being mixed with a gas in a combustion system.

Combustion Systems

The five common systems of combustion used in industrial furnaces are:

1. Two-pipe system.
2. Single-pipe system.
3. Two-valve control system.
4. Low-pressure proportional mixer system.
5. Central mixing system.

A simple pictorial representation of each is given in Fig. 3, together with two columns listing the factors affecting the selection of each. One

Table I – Composition of Commercial Gases; % by Volume

Gas	CO_2	O_2	N_2	CO	H_2	CH_4	C_2H_6	C_2H_4	C_6H_6	Specific Gravity
Natural Gas (Birmingham)	—	—	5.0	—	—	90.0	5.0	—	—	0.60
Natural gas (Pittsburgh)	—	—	0.8	—	—	83.4	15.8	—	—	0.61
Natural gas (So. California)	0.7	—	0.5	—	—	84.0	14.8	—	—	0.64
Natural gas (Los Angeles)	6.5	—	—	—	—	77.5	16.0	—	—	0.70
Natural gas (Kansas City)	0.8	—	8.4	—	—	84.1	6.7	—	—	0.63
Reformed natural gas (C_2H_6, 0.8%)	1.4	0.2	2.9	0.7	46.6	37.1	—	1.3	—	0.41
Mixed, natural and water gas	4.4	2.1	4.7	25.5	35.1	23.1	4.7	0.2	0.2	0.61
Coke oven gas	2.2	0.8	8.1	6.3	46.5	32.1	—	3.5	0.5	0.44
Coal gas (continuous verticals)	3.0	0.2	4.4	10.9	54.5	24.2	—	1.5	1.3	0.42
Coal gas (inclined retorts)	1.7	0.8	8.1	7.3	49.5	29.2	—	0.4	3.0	0.47
Coal gas (intermittent verticals)	1.7	0.5	8.2	6.9	49.7	29.9	—	3.0	0.1	0.41
Coal gas (horizontal retorts)	2.4	0.75	11.35	7.35	47.95	27.15	—	1.32	1.73	0.47
Mixed coke oven and carb. water gas	3.4	0.3	12.0	17.4	36.8	24.9	—	3.7	1.5	0.58
Mixed coal, coke oven and carb. water gas	1.8	1.6	13.6	9.0	42.6	28.0	—	2.4	1.0	0.50
Carburetted water gas	3.0	0.5	2.9	34.0	40.5	10.2	—	6.1	2.8	0.63
Carburetted water gas	4.3	0.7	6.5	32.0	34.0	15.5	—	4.7	2.3	0.67
Carburetted water gas (low gravity)	2.8	1.0	5.1	21.0	47.5	15.0	—	5.2	2.4	0.54
Water gas (coke)	5.4	0.7	8.3	37.0	47.3	1.3	—	—	—	0.57
Water gas (bituminous)	5.5	0.9	27.6	28.2	32.5	4.6	—	0.4	0.3	0.70
Oil gas (Pacific Coast)	4.7	0.3	3.6	12.7	48.6	26.3	—	2.7	1.1	0.47
Producer gas (buckwheat anthracite)	8.0	0.1	50.0	23.2	17.7	1.0	—	—	—	0.86
Producer gas (bituminous)	4.5	0.6	50.9	27.0	14.0	3.0	—	—	—	0.86
Producer gas (0.6 lb. steam per lb. of coke)	6.4	—	52.8	27.1	13.3	0.4	—	—	—	0.88
Blast furnace gas	11.5	—	60.0	27.5	1.0	—	—	—	—	1.02
Commercial butane	C_4H_{10} 93.0; C_3H_8 7.0									1.95
Commercial propane	C_3H_8 100.0									1.52

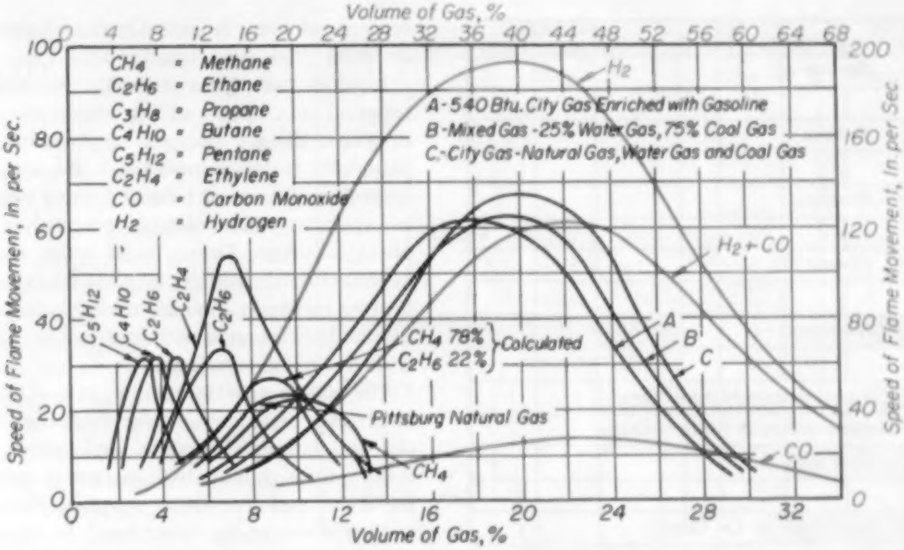


Fig. 1 – Speed of Uniform Movement of Flame in Various Gas-Air Mixtures in a 1-In. Tube. Note that curves in color are on a different scale from those in black

Table II – Combustion of Commercial Gases

Gas	Air*	Btu. per Cu. Ft.		Products of Combustion per Cu. Ft. of Gas				Ultimate % CO_2	Btu.†	Flame Temp., °F.
		Gross	Net	H_2O	CO_2	N_2	Total			
Natural gas (Birmingham)	9.41	1002	904	2.02	1.00	7.48	10.50	11.8	86.0	3565
Natural gas (Pittsburgh)	10.58	1129	1021	2.22	1.15	8.37	11.73	12.1	87.0	3562
Natural gas (So. California)	10.47	1116	1009	2.20	1.14	8.28	11.62	12.1	87.0	3550
Natural gas (Los Angeles)	10.05	1073	971	2.10	1.16	7.94	11.20	12.7	86.7	3550
Natural gas (Kansas City)	9.13	974	879	1.95	0.98	7.30	10.23	11.9	86.0	3535
Reformed natural gas	5.22	599	536	1.30	0.53	4.16	5.99	11.3	89.6	3615
Mixed, natural and water gas	4.43	525	477	1.01	0.64	3.55	5.20	15.3	91.7	3630
Coke oven gas	4.99	574	514	1.25	0.51	4.02	5.78	11.2	87.0	3610
Coal gas (continuous verticals)	4.53	532	477	1.15	0.49	3.62	5.26	11.9	90.7	3645
Coal gas (inclined retorts)	5.23	599	540	1.23	0.57	4.21	6.01	11.9	89.9	3660
Coal gas (intermittent verticals)	4.64	540	482	1.21	0.45	3.75	5.41	10.7	89.0	3610
Coal gas (horizontal retorts)	4.68	542	486	1.15	0.50	3.81	5.46	11.6	89.0	3600
Mixed coke oven and carb. water gas	4.71	545	495	1.04	0.62	3.85	5.51	13.9	90.0	3630
Mixed coal, coke oven and carb. water gas	4.52	528	475	1.11	0.50	3.71	5.32	11.8	89.3	3640
Carburetted water gas	4.60	550	508	0.87	0.76	3.66	5.29	17.2	96.2	3725
Carburetted water gas	4.51	534	493	0.75	0.86	3.63	5.24	17.1	94.2	3700
Carburetted water gas (low gravity)	4.61	549	501	0.98	0.64	3.70	5.31	14.7	94.3	3690
Water gas (coke)	2.10	287	262	0.53	0.44	1.74	2.71	20.1	96.6	3670
Water gas (bituminous)	2.01	261	239	0.47	0.41	1.86	2.74	18.0	87.2	3510
Oil gas (Pacific Coast)	4.73	551	496	1.15	0.56	3.77	5.48	12.9	90.5	3630
Producer gas (buckwheat anthracite)	1.06	143	133	0.22	0.32	1.34	1.88	19.4	70.5	3040
Producer gas (bituminous)	1.23	163	153	0.23	0.35	1.48	2.05	18.9	74.6	3175
Producer gas (0.6 lb. steam per lb. of coke)	1.00	135	128	0.17	0.34	1.32	1.82	20.5	70.3	3010
Blast furnace gas	0.68	92	92	0.02	0.39	1.14	1.54	25.5	59.5	2650
Commercial butane	30.47	3225	2977	4.93	3.93	24.07	32.93	14.0	90.5	3640
Commercial propane	23.82	2572	2371	4.17	3.00	18.82	25.99	13.7	91.2	3660

*Cubic feet required for combustion of 1 cu. ft. of gas. †Net, per cubic foot of products of combustion.

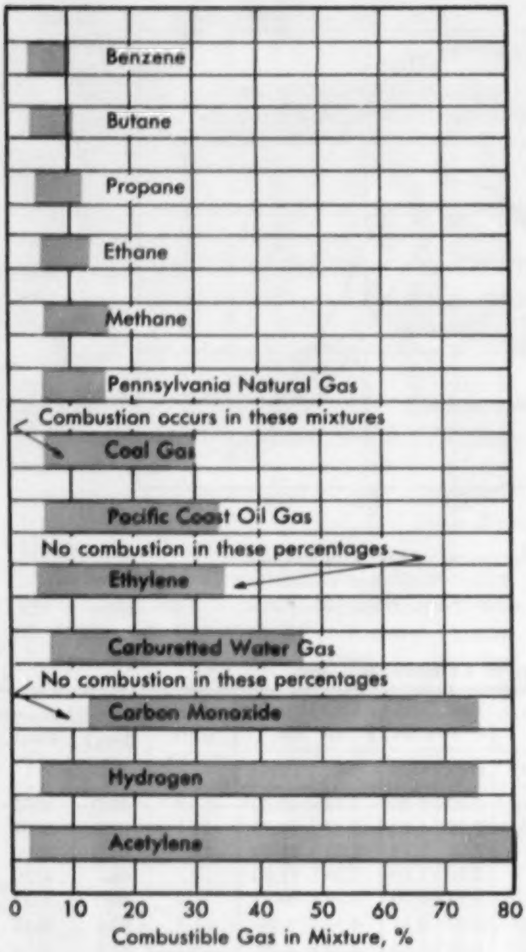


Fig. 2 – Inflammability Limits of Gases, as Determined by Research Dept., Standard Oil Co., of N.J.

column ranges the characteristics from minimum at top to maximum at bottom; the other column lists the characteristics in the opposite order of magnitude.

The two-pipe-system is very common. It employs an independent gas and air supply (at relatively high pressures) to the burner nozzle. Suitable regulating valves or automatic devices maintain a constant air-gas ratio at all ranges of burner input. The advantages of this are that it eliminates the possibility of backfiring and permits a wide range of operation.

Various modifications of the two-pipe system are in common use. In large openhearth furnaces and glass tanks, such a system for air and gas delays the ignition inside the furnace so flame can spread over the entire bath and provide the desirable high heat transfer rate.

In other two-pipe systems the gas and air are supplied to a burner of the nozzle mixing type, in which the air and gas are introduced independently to the burner head, the air-gas ratio controlled through a balanced valve system that incorporates either variable port valves or diaphragm valves. This is used quite widely for luminous flame burners in glass tanks and billet heating furnaces. A nozzle mixing type of burner cannot backfire and therefore has an extremely wide range of turndown.

The single-pipe system is one of the most commonly used methods for domestic, commercial and industrial heating applications. Mixing is done through a venturi; the gas is the entraining force and the air is supplied through the venturi sleeve at the mixer head. In the majority of low-pressure gas applications, 30 to 50% of the required air is supplied as primary air (through the mixer head) and the remainder as secondary air at the burner port. All or part of the air can be entrained by the injector; pressures at the burner head up to 4 in. can be developed at full air-gas mixture. On the other hand, a partial mixture can be made by the injector, and the rest of the required air can be supplied as secondary air to the tip of the burner (which is generally a retention type).

This system has the advantages of simplified piping. It is simple to adjust and regulate. The range of turndown is limited and it is not recommended where the internal pressure in the furnace is a factor of importance. Because of its simplicity, the system is not only one of the most commonly used but is probably one of the most abused.

Two-valve mixture control—In many applications where the range of turndown is not important and air and gas pressures are fairly constant, a simple two-valve mixing tee—consisting of an air jet limiting the amount of air and a side inlet for admission of gas—is the most economical mixing device. Its disadvantage is that it requires resetting of gas and air controls for each change in gas input. It is commonly used with any type of premix burner, but is not adaptable to any means of automatic control. This was a forerunner of the automatic mixing system which uses the "low-pressure proportional mixer."

The low-pressure proportional mixing system incorporates a venturi mixer to which is coupled a zero governor. About 30 years ago a

zero governor was developed that could supply gas at atmospheric pressure to a venturi tube, in a volume proportion to the suction produced by an auxiliary air stream. With this system temperature may be automatically and simply controlled by a single valve on the air supply, and yet meet a wide range of requirements, including large and small heat treating furnaces, atmosphere generators and kilns. Sometimes the burner and mixing devices are combined. One of the disadvantages of the proportional mixing system is that the area of air-jet must be carefully adjusted to the existing burner port. A recent development of a variable type jet has eliminated many of the difficulties previously encountered.

The central mixing system provides a controlled air-gas mixture from a single source by use of an area proportioning valve and a compressor. A properly designed mixer of this type maintains pre-set ratios regardless of output, permitting an individual burner to vary in consumption without affecting any of the other burners hooked up to the system.

Since the air and gas are completely premixed in the manifold, precautions must be taken to eliminate backfire in multiple installations by installing proper arrestors at the individual burners, and soft-head blowouts on large manifolds. The system is especially adaptable to installations requiring multiple burners of widely variable input, or where a central mixing system is desirable for multiple appliances requiring full pre-mix. Several designs are available which provide mixture pressures up to 4 or 5 lb., which is the maximum generally required. Because this particular mixing system can hold air-gas ratios very exactly, and has high range of turndown, it has a distinct advantage with multiple burners or multiple spot heating.

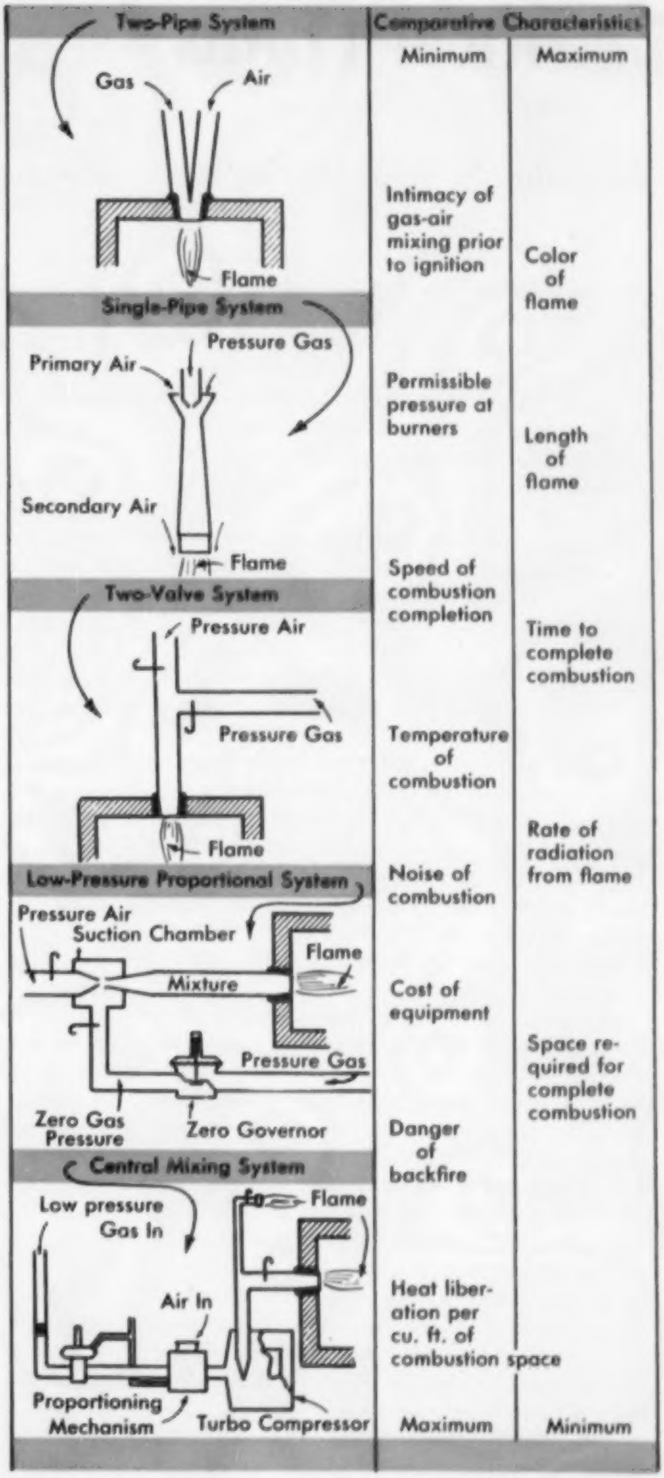


Fig. 3 – Comparative Characteristics of Combustion Systems

Critical Points

Evolution in Steel Melting

SOME IMPORTANT changes in steelmaking processes are already foreshadowed, if not already upon us. They speed up melting rates, and thus greatly reduce labor charges. Labor rates are prime factors in cost, having increased from about $1.45 per hr. in 1943 to $2.70 in 1954, these figures inclusive of social benefits. The quality of the metal produced is adequate. Some steelmen, not given to exuberant prophecy, have stated that no more stationary openhearth furnaces would be built except in locations where an unusual combination of conditions exist with respect to fuel supply, power, raw material and transportation.

Let us look at this evolution in steelmaking in the light of history.

Following the demise of the acid bessemer process in the United States about 1910, most American steel – 80 to 90% of it – has been made in the basic-lined stationary openhearth furnace. Steel executives have been so convinced that this practice would continue indefinitely that since 1945 over 30,000,000 tons of new capacity has been installed, mostly as basic openhearth stationary furnaces, with the very high investment cost of $100 to $300 per annual ingot ton, totaling about six billion dollars.

In Europe, on the other hand, 60% of the steel has been made by the basic bessemer process and 40% in the basic-lined stationary openhearth. These processes are, as is well known, adaptable to the high-phosphorus iron ores and pig irons indigenous to that region. The high nitrogen content of bessemer steel, both basic and acid, has tended to restrict its use to such products as bars, wire and small structural shapes (at least in the United States) and has excluded it from most flat products such as sheet, strip and plates which comprise almost 50% of all the tonnage. The great increase of welding and cold forming as fabrication processes has further decreased the applicability of steels high in nitrogen. It is obvious that the old bottom-blown bessemer process will some day be incapable of making the quality of steel demanded by modern industry, and European metallurgical literature contains many studies of ways and means of reducing the nitrogen content of air-blown metal.

Several technical and economic factors have also directed the attention of American steelmen to the numerous disadvantages of the basic-lined stationary openhearth furnace operations. Some of the more important of these are:

1. Inability of the openhearth to make high-quality carbon and alloy steels in competition with the electric furnace.
2. Very high capital investment cost – from $100 to $300 per annual ingot ton.
3. Low melting capacity; 15 tons per hr.
4. Very high and increasing labor costs; $3.00 per ton.
5. Increasing fuel costs.
6. High and increasing costs of refractories and repairs.

What is the alternative?

The basic arc furnace came into its own between 1941 and 1946. Retractable tops permitted rapid and economical charging of scrap. Additions of hot metal as large as 50% were found not only possible but advantageous. When furnaces were built as large as 100 tons capacity or larger, melting costs of simple tonnage steels were no higher than in openhearth furnaces. Hot metal charges reduced power costs; capital costs, repairs, labor and refractories are all cheaper than for the basic openhearths. The melter has better control of slags and the finishing stages. The cost of power has remained nearly stationary at about 1¢ per kw-hr.

The possibilities of the large electric furnace as a tonnage steel melter had hardly been appreciated and put into practice before we had another process, developed at Linz and Donawitz in Austria and already in operation by Dominion Foundries and Steel, Ltd. in Hamilton, Ont. This is the top blowing of pig iron with oxygen in a basic-lined vessel. Already it has been amply demonstrated that low-nitrogen rimming steels of good cold forming properties may readily be made when oxygen of over 95% purity is blown onto molten pig iron. The temperature developed is so great that 25% of cold scrap must be added to cool the bath. This is very cheap scrap melting. Oxygen consumption is about 2000 cu. ft. per ton of steel; its cost is less than $1.00 per ton of steel. One 40-ton vessel or converter will produce 80 tons of steel per hr. – at least four times the output of a conventional stationary openhearth furnace! Capital cost of such a plant is less than half the cost of an openhearth plant

of equal capacity. The over-all cost per ton of steel in the oxygen-blown converter should be much lower than in the openhearth furnace; several writers have given a range of $4.00 to $6.00 per ton. Obviously, this would represent a great annual saving in any plant producing over a million tons per year.

The impact of oxygen in steelmaking is just being felt in another direction – the desiliconizing of hot metal with oxygen down to about 0.20% Si max. before charging the hot metal into the openhearth or electric furnace. (Carbon also comes down to 2 to 3%.) When this operation is properly carried out, a low-silicon hot metal at a temperature of 2900° F. is charged, slag volume is reduced, ore and limestone charges are much smaller. Reasonable calculations show that for a charge of half scrap and half desiliconized hot metal instead of half scrap and half high-silicon hot metal from the mixer at 2400° F., a heat will melt in one fifth less time, save one quarter of the fuel, and make an over-all savings of about $4.00 per ton of steel. Moreover, slag volume is reduced over 60%, limestone 65% and ore charge 35%. This desiliconizing operation is highly beneficial in either the openhearth or electric furnace and more will undoubtedly be heard of this in the near future.

At the present time four steel plants have introduced the top-blown oxygen converter. One mill in India and one in Germany has been testing desiliconizied hot metal made with high-purity oxygen. One large American steel company has been successfully desiliconizing hot metal with air or oxygen-enriched air for several years.

These new practices will certainly spread as the advantages are more accurately assessed. A rapid evolution if not a revolution in steelmaking is upon us.

E. C. Wright
Consulting Editor

Arc-Cast Molybdenum – Fabrication of Parts

*By N. L. DEUBLE**

In this, the third in a series of articles about arc-cast molybdenum and molybdenum-base alloys, general characteristics that govern mechanical properties and, in turn, successful working methods are described. Most of the conventional methods of fabrication can be used with little or no modification.

Five general characteristics of molybdenum and its alloys should be considered when planning any working operation:

1. The mechanical properties of unalloyed molybdenum, and the four arc-cast alloys commercial today, depend largely on the amount of working done below the recrystallization temperature (so-called warm working). For best ductility, parts should be given at least a 50% reduction in area by warm working.

2. Full recrystallization gives lower strengths than do other prior treatments, so fully recrystallized molybdenum flows more easily in working. It does, however, have very poor bending

*Manager, Metallurgical Development Div., Climax Molybdenum Co., New York City.

properties although the tensile elongation is higher than in other prior conditions. Therefore, fully recrystallized molybdenum is used for the fabrication of parts only if no bending or deep drawing is to be done, or if mechanical properties after working are not important, or if subsequent processing will involve sufficient warm work to produce the necessary properties.

3. Relative to its high melting and recrystallization temperatures, the properties of molybdenum at room temperature are equivalent to those of steel at much lower temperature. The toughness and ductility of molybdenum are consequently not very high at room temperature although they increase markedly at temperatures somewhat above room temperature, so at least a moderate amount of heating is recommended for all working operations, except for fine wire and thin sheet.

4. Because of its high thermal conductivity and low specific heat, molybdenum heats and cools much more rapidly than steel.

5. The unusually high strength of molybdenum and its alloys at elevated temperatures requires more powerful presses and hammers than are needed for any of the common metals.

Heating for Working – Except with very small sizes, molybdenum can be heated to about 700° F. in air without excessive oxidation, provided the heating time is not too long. Hot oil is recommended as a heating medium when molybdenum sheet is to be deep drawn in this temperature range. When higher temperatures are needed, a controlled-atmosphere furnace, a salt bath or induction heating may be used. The controlled-atmosphere furnace may be operated with either a vacuum, inert gas or a reducing atmosphere (which does not need to be strongly reducing). The molybdenum should not come in contact with slag or scale on the bottom of a furnace.

Die forging can be done by conventional methods, but not too much deformation is possible in one heat because the piece will cool rapidly. If mechanical properties are of no interest, a temperature of 2600 to 2800° F. is preferred for easy workability. If mechanical properties are to be controlled, forging and reheating temperatures must also be controlled, to provide for at least 50% reduction by warm work below the recrystallization temperature. Reductions of as much as 90% have been made without any difficulty. Unalloyed molybdenum may be forged as low as 1700° F., but most alloys will crack if much work is done under 1900° F.

Pickling and Cleaning – Removal of heavy oxide coatings was discussed in Part II (see *Metal Progress*, May 1955, p. 89). A light oxide film on the surface of a part is often removed by heating for 10 to 30 min. in hydrogen at 1500 to 1800° F. and cooling in the same atmosphere. Ordinary cleaning or degreasing can be done by conventional methods. Parts for electronic tubes, which must be chemically clean, can be treated with the hot chromic acid solution commonly used for cleaning glass.

Forming, Bending, Spinning and Deep Drawing – With sheet up to about 0.020 in. thick, these operations can be carried out by conventional procedures at room temperature, but it is better practice to heat both the work and the tools. Heavier material must be heated to 200 to 1000° F., depending on size. Aluminum bronze or other material with a low coefficient of friction is preferred for tools for spinning and deep drawing. Highly chlorinated oils are satisfactory lubricants for deep drawing.

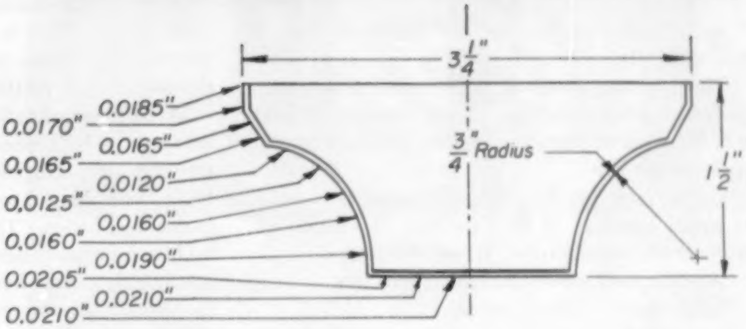
The considerable reduction in cross section which can be made by spinning is shown in Fig. 10, a cone spun from 0.020-in. sheet which was warmed with a torch during spinning. One company making magnetron parts draws cups 1⅛ in. deep by ½ in. diameter from 0.025-in. sheet by warming the sheet and the tools slightly. Wall reductions of as much as 22% have been made between anneals.

A new technique for deep drawing appears promising, since as many as six and seven draws without intermediate stress relieving have been successfully made with regular molybdenum sheet. In this technique (described in "Deep Drawing of Molybdenum", by F. Duckworth, *Machinery* (London), Vol. 84, 1954, p. 389 to 390) the usual process of drawing the cup through the die is revised; special tools are used to prevent wrinkling and to keep the molybdenum under tension while it is being drawn.

Machining and Grinding

Although general machining practices for arc-cast molybdenum are similar to those for molybdenum metal from powder-metallurgical processes, the former gives a much better finish and has less tendency to spall and crack when thin sections are machined. Unalloyed molybdenum in the as-cast condition and after warm working has a hardness ranging from Brinell 196 to 275, but is considerably more abrasive than steel at the same hardness. Prior treatment has little effect on the machinability of molybdenum.

Fig. 10 – Molybdenum Cone Produced by Spinning. Work and tool heated by torch



Either high speed steel or sintered carbide tools can be used for machining. Cast cobalt-base alloys have not proved satisfactory. Tool angles and rakes are in general similar to those for machining cast iron. A 50-50 mixture of chlorinated oil and trichloroethylene, or highly chlorinated oil is recommended as a cutting fluid.

Turning – Molybdenum can be turned to a good surface finish if the proper tools and lubrication are used. For machining of heavy sections or removing considerable stock, good results are obtained with high speed tools having a generous rake and usually with no lubrication. Speeds of about 50 ft. per min., with feeds of 0.010 to 0.020 in. per revolution and depths of cut up to ⅛ in., are practical.

For finish turning, general-purpose straight tungsten carbide tools should be used. Recommended tool form is:

Back rake	0°
Side rake	6°
Edge cutting angle	18°
Relief	6°
Nose radius	0.010 in.

Cutting speed should be about 25 ft. per. min., feed 0.002 in. per revolution, and depth of cut 0.010 in. A recommended cutting lubricant is one part trichloroethylene and one part of a highly chlorinated oil.

Drilling, Reaming, Tapping and Threading – High speed steel is recommended for drilling. The tool should have a point angle of 118°. Cutting speed should be 25 ft. per min. and feed 0.005 in. per revolution. For the lubricant a highly chlorinated oil is recommended. It is best to relieve the pressure on the tool after drilling to a depth of about four times the diameter of the drill, so as to remove the rather abrasive chips. Good results can be obtained if the drill is mounted so it feeds from below the piece to allow the chips to fall out automatically. For good finish and accurate size, holes should be bored or honed after drilling.

Reaming should be avoided if possible because the cutting edge of the tool is dulled quickly, and binding occurs, causing tool breakage. On the other hand, no difficulties are encountered in tapping and threading. Threads can be cut with high speed steel on a lathe, or they can be roll formed if the metal and die are heated to approximately 325° F. Die threading is not recommended in the present state of the art.

Milling and Shaping – With high speed steel tools, shaping is preferred to milling because shaper tools last longer and are easier to regrind. However, excellent results have been reported for milling with carbide-tipped cutters.

Grinding – Molybdenum is not hard, as measured by indentation methods, but it is abrasive and resists grinding. No measurable difference has been found in the grinding characteristics of metal in stress-relieved and recrystallized conditions. Some experiments indicated that molybdenum could not be cracked by using heavy cuts, but cracking has been encountered with exceptionally light cuts (0.0002 to 0.0005 in. per pass).

Recommended Grinding Wheels

	CARBORUNDUM	NORTON
Surface grinding	AA60-K8-V40 or GA60-K6-V10	32A60-G12VBEP (dry) 19A46-J5VG (wet)
Cylindrical	DA465-L6-V11	19A60-L5VG
Cut-off	A601-R-RR	A601-N6R-50 with F sides
Bench	A36-N6V30	A36-N5VBE

A modification of the feed and speed eliminated this difficulty.

The grinding procedures given below are suggested starting points; necessary changes, if any, will be evident from the results obtained in the preliminary work.

For surface grinding the work must be cooled to avoid burning. A 60:1 mixture of soluble oil is generally satisfactory. Wheel data are:

Wheel speed – 6000 surface ft. per min.

Table speed – 50 ft. per min.

Cross feed – 1/32 in. per table traverse.

Infeed – Dry, 0.002 in.; wet 0.005 in.

For cylindrical grinding, cooling is as important as for surface grinding, and the same coolant can be used. Data for the operation are:

Wheel speed – 6500 surface ft. per min.

Work speed – 100 surface ft. per min.

Traverse rate – One third width of wheel per revolution with 0.001-in. infeed gave 30 M.I. rms.; one sixth width of wheel per revolution with 0.0005-in. infeed gave 12 M.I. rms.

Grinding wheels recommended by the manufacturers are shown in the tabulation above.

Joining

Molybdenum is often joined by brazing or riveting, but less frequently by welding. Considerable development work and several large-scale research programs on brazing and welding are under way, so some of the present problems should be solved in the not-too-distant future. Nevertheless, in planning joining methods, certain basic facts should be kept in mind.

Welding – A number of government-sponsored investigations on welding have been carried out at Battelle Memorial Institute, Massachusetts Institute of Technology and Westinghouse Electric Corp.* These studies have shown that arc-cast molybdenum can be welded without porosity and with freedom from cracks. This is generally not true of commercially available molybdenum made by powder-metallurgy methods.

Molybdenum has been successfully welded for many years by a number of methods. Resistance welding of small molybdenum parts has long been a commercial practice in the lamp and electronic industries. The most satisfactory welds in heavier sheets and parts are probably those made with atomic hydrogen or inert gas shielded arc with tungsten electrodes, with or without filler wire additions. The welds show brittle characteristics in bending at room temperature, but become quite ductile at 300 to 400° F. A large aircraft company found that arc-cast molybdenum could be welded into tubular sections and then expanded approximately 10% at 800° F. despite the brittleness of the welds at room temperature.

The ductility of molybdenum is adversely affected by even small amounts of oxygen. Therefore, for best ductility, welding must be done in a vacuum or a controlled atmosphere.

The high melting point, the high strength at elevated temperatures, and the high thermal conductivity of molybdenum raise problems in some types of welding, particularly the resistance methods.

Brazing – The ductility of brazed joints may be superior to welded joints, provided the time at temperatures above about 1700° F. is kept to a minimum. Brazing, however, is not suitable for all uses. Also, filler alloys that are adaptable to relatively low-temperature brazing (and

---

*"Welding of Molybdenum", by W. H. Kearns, H. B. Goodwin, D. C. Martin and C. B. Voldrich, U. S. Atomic Energy Commission, BMI-703, Sept. 1, 1951 (Contract No. W-7405-eng-92).

"Molybdenum Welding", by J. H. Johnston and J. Wulff, WADC Technical Report 53-260, July 1953 (Aeronautical Research Laboratory Contract No. AF 33 (616)-361 RDO No. 477-641).

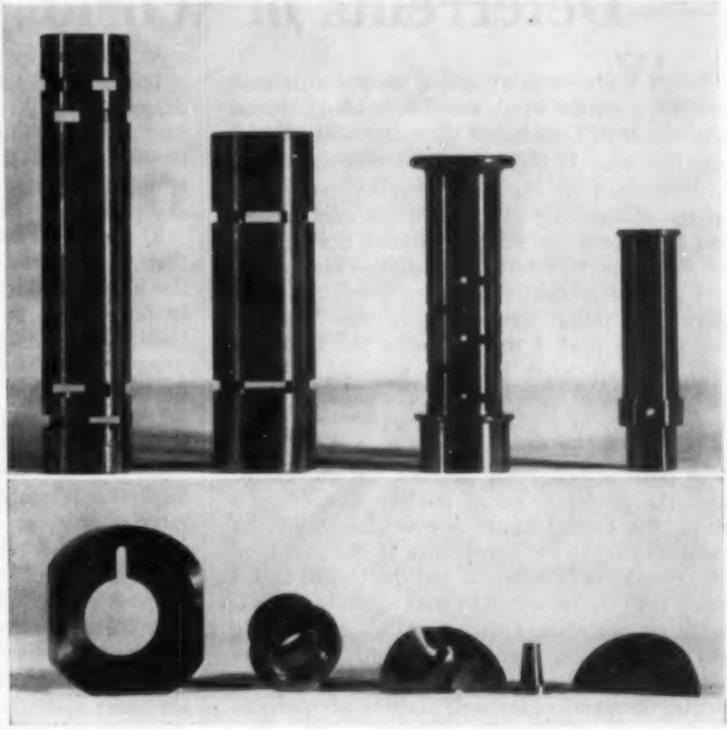
"The Improvement of the Ductility of Molybdenum Weldments", by W. H. Kearns, L. E. Olds, D. C. Martin and R. B. Fischer, Summary Report to Office of Naval Research, Navy Department, July 14, 1953 (Contract N9onr 82101, Task Order N9onr 82101, Project NR 039-003).

"Production of Sound Ductile Joints in Molybdenum", by M. I. Jacobson, D. C. Martin and C. B. Voldrich, WADC Technical Report 53-401, October 1953 (Materials Laboratory Contract No. AF 33 (616)-10 RDO No. R-446-48).

"Some Recent Advances in the Welding of Molybdenum", by W. H. Kearns, H. B. Goodwin, E. Eichen and D. C. Martin, *Welding Journal*, Vol. 32, 1953, p. 1082.

"Joining of Molybdenum", by W. N. Platte, WADC Technical Report 54-17, January 1954 (Materials Laboratory Contract No. AF 18 (600) 114 RDO No. 446-48 (L-G).

Fig. 11 – Parts Machined From Arc-Cast Molybdenum; (Top) from Unalloyed Bar Stock for Use in Magnetrons, (Bottom) for Brazing Die



which avoid embrittlement of the parent metal) are unsatisfactory for high-temperature applications. Copper or silver brazing alloys are usually chosen where temperatures in service are not high. Many brazing materials have been tried for high-temperature structural applications, but as yet none has proved completely satisfactory.

Mechanical Joining – Mechanical means of joining (as riveting) offer possibilities for some applications although not for parts that must be gas or liquid tight. Little has yet been done to determine the feasibility of combinations of mechanical joints (such as lock seams) with subsequent brazing or welding.

Recrystallizing and Stress Relieving

As will be shown in Part IV, fully recrystallized molybdenum has lower strength and generally lower toughness at room and elevated temperatures than material in the as-rolled or stress-relieved conditions. Therefore, full recrystallization is ordinarily used only as an intermediate treatment to refine the grain prior to further warm working, or to reduce the hardness so that large reductions can be made by warm working without cracking. In some special circumstances metal is fully recrystallized to obtain a low strength similar to that of a weld and its heat-affected zone, so a weldment will respond uniformly to expansion or other working.

The required minimum temperature for full recrystallization depends not only on composition but also on prior structure and time at temperature. Consequently, precise schedules must be determined by trial. The minimum temperatures needed for full recrystallization in one hour of ⅝-in. diameter bars (produced by rolling 2¼-in. round billets at 2200 to 1900° F.) were found to be as follows:

unalloyed	2150° F.
0.3% Cb	2200
0.5% Ti	2450
1% V	2150

Controlled atmospheres, as mentioned above under "Heating for Working", are necessary.

Stress relieving may be used either as an intermediate or final heat treatment. The maximum temperature for stress relieving unalloyed molybdenum is 1830° F.; some of the molybdenum-base alloys with higher recrystallization temperatures may be stress relieved at proportionately higher temperatures. Normally the molybdenum is rapidly cooled in air after stress relieving, but the ductility of severely worked sheet may be improved by slow cooling.

Deterrents of World War III*

We live in a period, unique in human history, when the whole world is divided between the creeds of Communist discipline and individual freedom. At the same time, this division is accompanied by the possession by both sides of the obliterating weapons of the nuclear age. We have force and science, hitherto the servants of man, now threatening to become his master.

I am not pretending to have a solution for a permanent peace between the nations. We pray for it. Nor shall I try to discuss the cold war which we all detest, but have to endure. I shall only venture to offer to the House some observations mainly of a general character.

What is the present position? Only three countries possess, in varying degrees, the knowledge and the power to make nuclear weapons. Of these, the United States is overwhelmingly the chief. Owing to the breakdown in the exchange of information between us and the United States since 1946 we have had to start again independently on our own. Fortunately, we have made our own atomic bombs. Although the Soviet stockpile of atomic bombs may be greater, British discoveries may well place us above them in fundamental science.

Confronted with the hydrogen bomb, we have started to make that one, too. It is this grave decision which we are discussing this afternoon. There is an immense gulf between the atomic and the hydrogen bomb. The atomic bomb, with all its terrors, did not carry us outside the scope of human control or manageable events in thought or action, in peace or war. But when the chairman of the United States Congressional Committee gave the first comprehensive review of the hydrogen bomb, the entire foundation of human affairs was revolutionized, and mankind placed in a situation both measureless and laden with doom.

A quantity of plutonium probably less than would fill this box on the table would suffice to produce weapons which would give world domination to any Power which was the only one to have it. There is no absolute defense against the hydrogen bomb. Nor is any method in sight by which any country can be guaranteed against the devastating injury which a score of them might inflict on wide regions.

What ought we to do? Which way shall we turn to save our lives and the future of the world? What would lie before the little children, playing their merry games, if God wearied of mankind?

*Verbatim extracts from statement by the Prime Minister of Great Britain, Sir Winston Churchill, before the House of Commons, March 1, 1955.

The best defense would of course be *bona fide* disarmament all round. This is in all our hearts. But sentiment must not cloud our vision. The long history and tradition of Russia makes it repugnant to the Soviet Government to accept any practical system of international inspection.

A second difficulty lies in the circumstance that, just as the United States has, we believe, the overwhelming mastery in nuclear weapons, so the Soviets and their Communist Satellites have immense superiority in what are called "conventional" forces — the sort of arms and forces with which we fought the last war.

Unless a trustworthy and universal agreement upon disarmament, conventional and nuclear alike, can be reached and an effective system of inspection is established and is actually working, there is only one sane policy for the free world in the next few years. That is what we call defense through deterrents. This we have already adopted and proclaimed. These deterrents may at any time become the parents of disarmament, provided that they deter. To make our contribution to the deterrent we must ourselves possess the most up-to-date nuclear weapons, and the means of delivering them. We, too, must possess substantial deterrent power of our own.

Should war come, which God forbid, there are scores of airfields from which the Soviets could launch attacks. It is essential to our deterrent policy and to our survival to have, with our American allies, the strength to paralyze these potential assaults in the first few hours. There are also big administrative and industrial targets behind the Iron Curtain, and any effective deterrent policy must have the power to paralyze them all at the outset, or shortly after. There are also the Soviet submarine bases and other naval targets.

Unless we make a contribution of our own — that is the point which I am pressing — we cannot be sure that in an emergency the targets which would threaten us most would be given what we consider the deserved priority, in the first few hours. These targets might be of such cardinal importance that it would really be a matter of life and death for us.

Meanwhile, the United States has many times the nuclear power of Soviet Russia and they have far more effective means of delivering. Our moral and military support of the United States and our possession of nuclear weapons of the highest quality and on an appreciable scale, together with their means of delivery, will greatly reinforce the deterrent power of the free world, and will strengthen our influence within the free

world. That, at any rate, is the policy we have decided to pursue.

A vast quantity of information, some true, some exaggerated much out of proportion, has been published about the hydrogen bomb. The truth has inevitably been mingled with fiction, and I am glad to say that panic has not occurred. The world goes on its daily journey despite its somber impression and earnest longing for relief.

I shall content myself with saying about the power of this weapon, the hydrogen bomb, that apart from the blast and heat effects there are the consequences of "fall-out" or wind-borne radioactive particles, both an immediate direct effect on exposed human beings and an indirect effect on animals, grass and vegetables which pass on these contagions to human beings through food.

This would confront many who escaped the direct effects of the explosion with poisoning, or starvation, or both. Imagination stands appalled.

But a curious paradox has emerged. Let me put it simply: After a certain point has been passed it may be said, "The worse things get the better." The broad effect of the latest developments is to spread to a vast extent the area of mortal danger. This should certainly increase the deterrent upon Soviet Russia by putting her enormous spaces and scattered population on near-equality of vulnerability with our small, densely populated island and with Western Europe.

It may well be that we shall by a process of sublime irony have reached a stage in this story where safety will be the sturdy child of terror, and survival the twin brother of annihilation.

Although the Americans have developed weapons capable of producing all the effects I have mentioned, we believe that the Soviets so far have tested only a bomb of intermediate power. There is every reason to believe, however, that they should develop some time within the next four, three or even two years more advanced weapons and full means to deliver them on North American targets.

Thus, the threat of hydrogen attack on these islands lies in the future. It is not with us now. The only country which is able to deliver today a full-scale nuclear attack with hydrogen bombs at a few hours' notice is the United States.

It is conceivable that Soviet Russia might attempt a surprise attack with such nuclear weapons as she has already. American superiority in nuclear weapons, reinforced by Britain, must, therefore, make it clear that no such surprise attack would prevent immediate retaliation on a far larger scale. Not only must the nuclear superiority of the Western Powers be stimulated in every possible way, but their means of delivery of bombs must be expanded, improved, and varied. As one might say to them, "Although you might kill millions of our peoples, and cause widespread havoc by a surprise attack, we could, within a few hours of this outrage, certainly deliver many times the weight of nuclear material which you have used, and continue retaliation on that same scale."

I must make one admission, and any admission is formidable. The deterrent does not cover the case of lunatics or dictators in the mood of Hitler when he found himself in his final dugout.

All these considerations lead me to calculate, therefore, that world war will not break out within three or four years. In that time (it may be even less) the scene will be changed. The Soviets will probably stand possessed of hydrogen bombs and the means of delivering them. They may then have reached a stage, not indeed of parity with the United States and Britain, but of what is called "saturation".

"Saturation" in this connection means the point where, although one Power is stronger than the other, perhaps much stronger, both are capable of inflicting crippling or quasi-mortal injury on the other with what they have got. It does not follow, however, that the risk of war will then be greater. Indeed, it is arguable that it will be less, for both sides will then realize that it would result in mutual annihilation.

Major war of the future will differ, therefore, from anything we have known in the past in this one significant respect – that each side, at the outset, will suffer what it dreads the most, the loss of everything that it has ever known of. The deterrents will grow continually in value. In the past, an aggressor has been tempted by the hope of snatching an early advantage. In future, he may be deterred by the knowledge that the other side has the certain power to inflict swift, inescapable and crushing retaliation.

To conclude: Mercifully there is time and hope if we combine patience and courage. All deterrents will improve and gain authority during the next 10 years. By that time the deterrent may well reach its acme and reap its final reward. The day may dawn when fair play, love for one's fellow men, respect for justice and freedom, will enable tormented generations to march forth serene and triumphant from the hideous epoch in which we have to dwell.

Meanwhile, never flinch, never weary, never despair.

Book Review

Resources for Canada's Steel Industry

Reviewed by E. E. THUM

SOME ASPECTS OF THE CANADIAN IRON AND STEEL INDUSTRY WITH PARTICULAR REFERENCE TO BRITISH COLUMBIA, by G. P. Contractor, British Columbia Research Council, Technical Bulletin No. 21, University of British Columbia, Vancouver 8, Canada, 1954, 175 p., 8½ x 11 in., paper bound. $4.00.

EVER SINCE college days (and that's a long time) I have wanted to be in on the arguments which precede the location of a modern steel mill, such as the Steel Corporation's Fairless plant on the Delaware river. My professor at the School of Mines explained that it was a problem akin to differential calculus; summation of costs due to several factors should be minimized – cost of mining desirable iron ore, and freight to the proposed site; cost of mining and coking coal, and freight to the furnaces; cost of recruiting and maintaining the manpower; cost of shipping the product to the customer. I tried to apply these principles to the sizable steel plant of the Colorado Fuel & Iron Co. in my home town (Pueblo). Iron ore came from Wyoming, 325 miles north; coal was much nearer, 75 miles south; manpower came from the pleasant growing city; but where were the customers? The railroads and mines kept the rail mill working continually. The ranches required lots of barbed wire fencing and baling wire. Narrow strip called "cotton ties" went into the Southwest by the trainload. But the varied demands of the ultimate consumer were supplied by two or three small stands in the merchant mill. The Pueblo steel plant seemed to have everything but the consumers.

An even more difficult situation appears to confront Dr. Contractor in this careful study of conditions in British Columbia. Present steel production (average for 1951, 1952, 1953) is about 40,000 tons from eight shops working at about 65% of capacity. Eight of the eleven furnaces – all electric – are quite small, 2 tons or less, and doubtless are foundry furnaces. The largest furnace is of 12½ tons capacity; its product is rolled into small bars, angles, and flats.

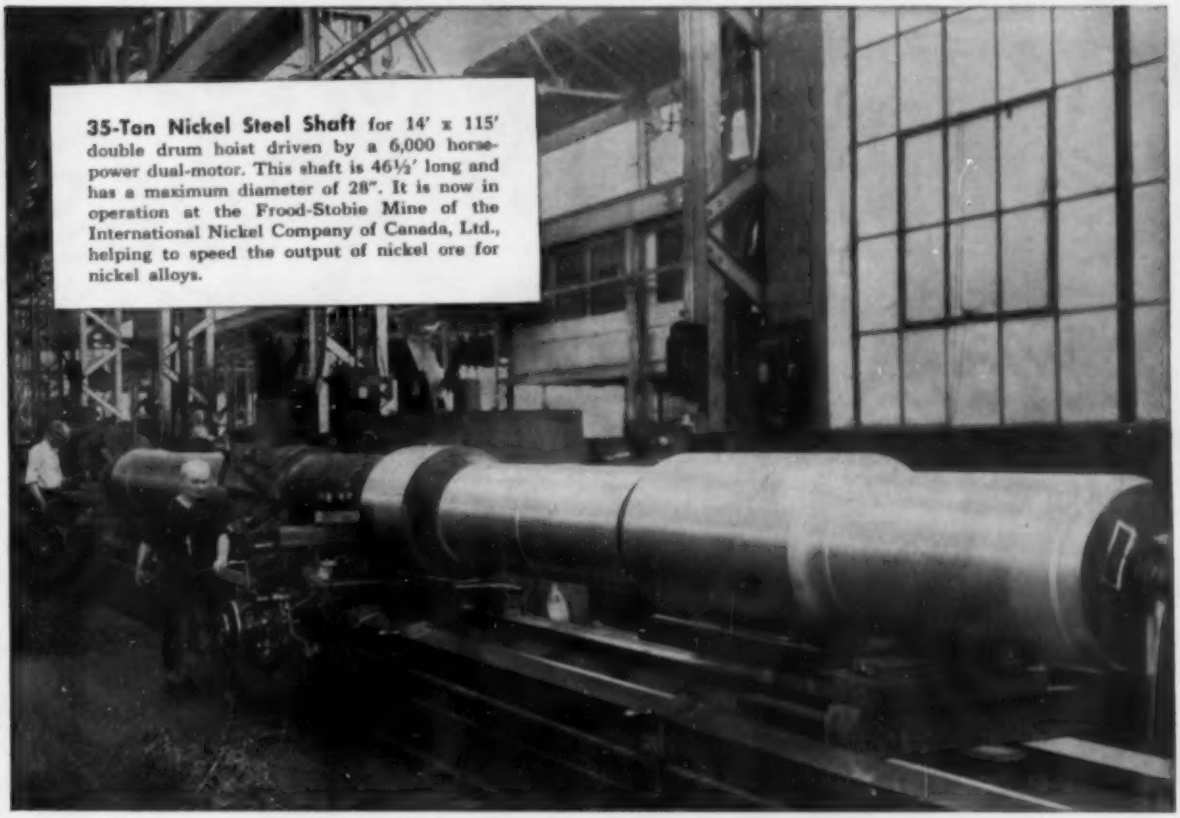
40,000 tons in British Columbia is about 1% of the annual steel production of all of Canada, and it is clear out of line with the population – about 1,250,000 for British Columbia and 14,500,000 for Canada – and much below the actual consumption of its main industries. These are forestry, mining, agriculture, fisheries, electric power and new construction – all either sparing in consumption of iron or steel products or demanding heavy and specialized materials which cannot be economically produced in plants of moderate tonnage. (Even Sweden, you know, imports all but its smallest structural shapes.)

Likewise it is estimated that annual consumption of British Columbia and its neighboring provinces amounts to about 20,000 tons of foundry iron and 225,000 tons of rolled steel of moderate cross section – perhaps half being tin plate. Even if all this could be produced at one place it would hardly be enough for an integrated plant with one modern blast furnace.

However, a supposed shortage in domestic scrap for any expanded production of ingots prompted this inquiry by the British Columbia Research Council into the iron ore, coal and power resources of the province. For this reason, the author turns his attention to the Tysland-Hole electric furnace for making pig iron from iron ore. Some 25 furnaces of this sort are in operation at 18 different locations in Europe, and ten more are under construction. Their output ranges from about 50 tons per day (6500-kva. power input) to 300 tons per day (33,000-kva.). This report by Dr. Contractor contains the best account of this furnace and the economics of its operation which this reviewer has ever seen.

So the problem of blast furnace coke (produced only in the Crowsnest field in the extreme southeastern corner of the province, 800 miles away from the populous area) is "solved" by eliminating half of it from the burden and using electric power in its place. Iron ore, the basic essential, however, is another thing. High-sulphur magnetite concentrates are now being shipped to Japan from small deposits on Vancouver Island; 1,000,000 short tons in 1953. And the author continues: "Other commercial iron ore deposits in British Columbia are far from adequate for starting a sizable pig iron industry."

As my favorite lecturer on electronics, George Goebel, would say, "And there we are."



35-Ton Nickel Steel Shaft for 14' x 115' double drum hoist driven by a 6,000 horsepower dual-motor. This shaft is 46½' long and has a maximum diameter of 28". It is now in operation at the Frood-Stobie Mine of the International Nickel Company of Canada, Ltd., helping to speed the output of nickel ore for nickel alloys.

How nickel strengthened the shaft for
Canada's highest powered mine hoist

IN LARGE FORGINGS such as this giant shaft, high tensile and elastic properties do not come easily.

Liquid quenching of heavy forgings is usually impractical. Even when the shape is such that this treatment may be safely applied, the section sizes involved often restrict cooling to rates which render the quench ineffective.

Increased strength, hardness, toughness and other mechanical properties in a large forging depend to a great extent upon selection of alloy content.

Accordingly, to attain maximum strength and toughness in the shaft of Canada's highest powered mine hoist, at our own Frood-Stobie mine, we specified a shaft forged of 3½% nickel steel . . .

Because nickel, either alone or in combination with other alloying elements, provides a number of advantages.

For one thing, it has a strengthening effect on ferrite . . . independent of carbon content or heat treatment of the steel.

For another, it lowers the rate and temperature of the upper transformation, thus inducing better response to the necessarily milder heat treatments used. And it reduces grain growth.

Whenever you face a metal problem, let us help you make a selection that will meet your particular fabricating and service requirements. Send us details of your applications, for our suggestions.

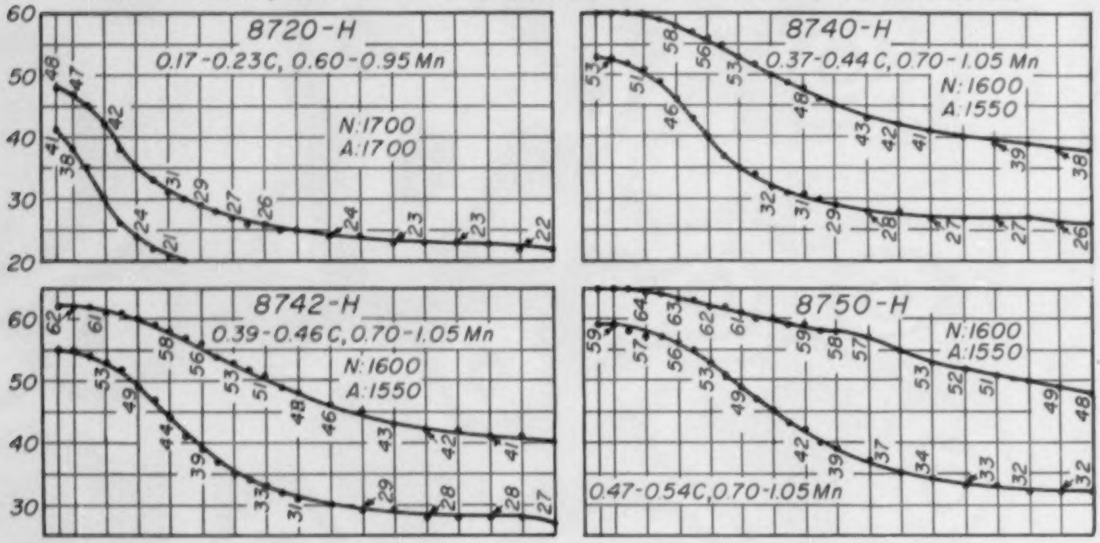
INCO
TRADE MARK

Double Drum Hoist for the Frood-Stobie Mine, during course of shop erection by the builder, The John Bertram & Sons Co., Ltd., Dundas, Ontario. Spiders that support the steel shell of the hoisting drum were cast in an iron containing 1½% nickel . . . to assure adequate strength in the 74,600-pound drum-spider assembly. This hoist, operated by push button control from a station far underground, can lift skips containing 15 tons of nickel-copper ore, at an average rate of 14,000 tons daily.

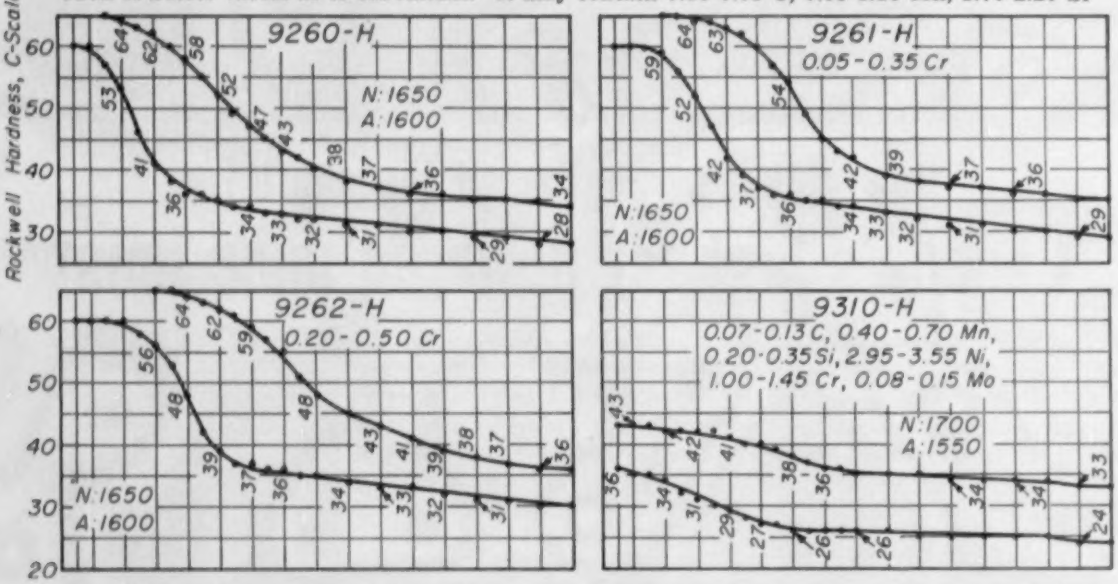
THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N.Y.

Standard H-Steels, 8720-H to 9850-H

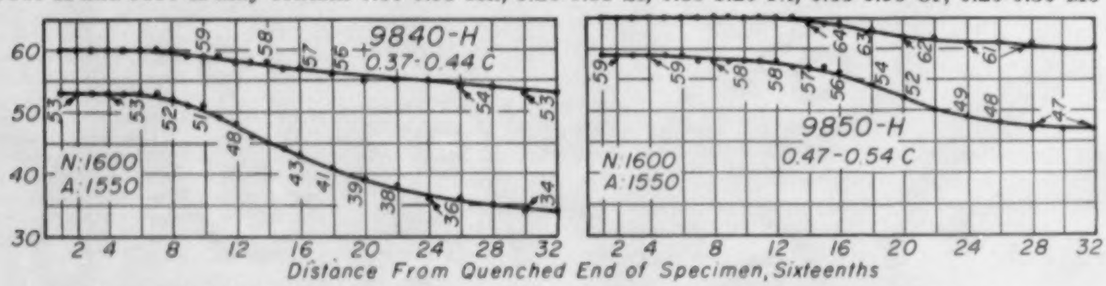
87xx-H Series may contain 0.20-0.35 Si, 0.35-0.75 Ni, 0.35-0.65 Cr, and 0.20-0.30 Mo



926x-H Series varies as to chromium. It may contain 0.55-0.65 C, 0.65-1.10 Mn, 1.70-2.20 Si



9840-H and 9850-H may contain 0.60-0.95 Mn, 0.20-0.35 Si, 0.80-1.20 Ni, 0.65-0.95 Cr, 0.20-0.30 Mo



N means normalizing temperature for forged or rolled material; A means austenitizing temperature (both as recommended by S.A.E.).

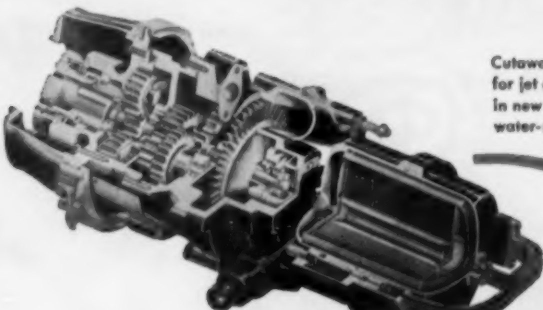
Hardness limits are specified in Rockwell C-scale units (no fractions) and can be scaled from the plotted points where not labeled at even sixteenths.

A.I.S.I. list of February 1954.

Rapid deep case

for jet engine starter clutch

with new AEROCARB® carburizing compounds



Cutaway of a General Electric gas turbine starter for jet engines shows clutch components they carburize in new high-speed, high-temperature, water-soluble AEROCARB Carburizing Compounds.

Sleek new Martin B-57 jet light bomber has starters housed in streamlined pods seen at each engine air intake opening.

Clutch mechanisms for gas turbine starters must deliver tremendous power to bring jet engines to starting speed. To get the toughness and strength they need, General Electric Company's Aircraft Accessory Turbine Dept. at Lynn, Massachusetts, carburizes these parts in Cyanamid's new, high-speed, high-temperature AEROCARB S and (as the bath replenisher) AEROCARB R Carburizing Compounds.

Chief feature of these new AEROCARB compounds is deep and rapid penetration with minimum distortion. Many of the parts require 0.060" case depth, which G-E achieves at 1650-1750° F in just 8-9 hours with AEROCARB water-soluble salts. They use the same salt bath for their short time, shallow case work. Drag-out from this bath is low; wash-off is fast, easy, and complete with warm water.

These remarkable new AEROCARB carburizing compounds can solve your case hardening problems—give you high quality results in less time and at lower cost. The attached coupon is for your convenience.

Cyanamid's heat treating compounds include:	Other products for metal processing include:
AEROCASE® Carburizing Compounds	AEROMET* Metallurgical Additive
AEROCARB® Case Hardening Compounds	Metallic Stearates
AEROHEAT® Heat Treating Compounds	Surface Active Agents
	Acids and other Heavy Chemicals
	*Trade-mark

MP6-55

AMERICAN CYANAMID COMPANY

METAL CHEMICALS SECTION

30 Rockefeller Plaza, New York 20, N. Y.

☐ Send technical data sheet on AEROCARB S

☐ Have technical representative call

Name________ Position________

Company________

Address________

City________ State________

In Canada: North American Cyanamid Limited, Toronto and Montreal

Bausch & Lomb Salutes:

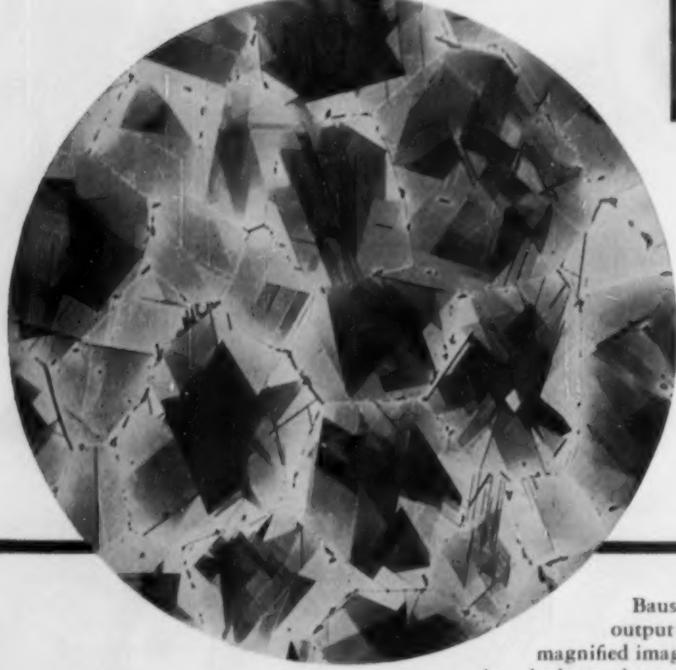
R. D. Buchheit

J. E. Boyd

A. A. Watts

F. C. Holden

—Grand Prize Winners, A.S.M. Metallographic Exhibit



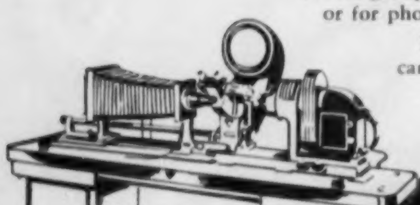
GRAND PRIZE WINNERS
for the best photomicrograph in its class and in the exhibit—Messrs. Buchheit, Boyd, Watts and Holden, Battelle Memorial Institute, Columbus, Ohio.

THEIR AWARD-WINNING PHOTOMICROGRAPH, MADE WITH BAUSCH & LOMB EQUIPMENT—"Alpha Formation in a Beta Titanium Alloy." 100× magnification.

Bausch & Lomb Metallographs help industry boost output and maintain quality by providing detailed magnified images—visual or photographic—for routine work and advanced research.

Ease and comfort are basic design features of the B&L Balphot Metallograph—one of a complete line of metallographic equipments. You sit relaxed, with all major controls within effortless reach. A flick of a switch provides clear, sharp images for microscopy . . . for group viewing (with exclusive Magna-Viewer projector screen) . . . or for photomicrography.

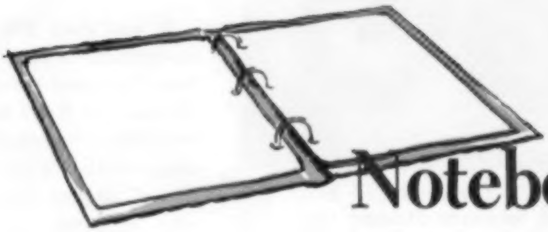
Find out how these faster, easier, completely dependable analyses can help you save on time and materials. Write for Catalog E-232, and for complete expert advisory service. No obligation, of course. Bausch & Lomb Optical Co., 63842 St. Paul Street, Rochester 2, New York.



America's only complete optical source . . . from glass to finished product.

BAUSCH & LOMB

SINCE 1853



Notebook...

Improved Stripping Solution

*By R. C. SPOONER and J. M. ROBERTS**

According to studies we have made, anodic oxide films can be removed from aluminum surfaces with the DeSy and Haemers'† solution in similar fashion to that developed by Lacombe and Beaujard‡ with Jacquet's electropolishing solution and without the danger inherent in using the latter. No attempt seems to have been made to employ this fast and useful technique with other solutions in order to avoid the potential explosive hazards of Jacquet's perchloric acid-acetic anhydride solution.

Aluminum sheet panels ($1.3 \times 10 \times 0.05$ cm.) of 99.87% purity were anodized in sulphuric acid under conventional conditions and the films (about 28μ thick) were removed by anodic treatment using 60 to 70 v. for periods of ¼ to 2 min. in a DeSy and Haemers' solution cooled to 59° F. and mildly agitated. The solution was made up using methanol instead of the ethanol commonly employed. The top of the specimen to which electrical contact was made was not anodized and the aluminum on the immersed panel edges was exposed by filing off the oxide film before immersion. The initially small current (2 to 5 amp.) remained constant for a short period (5 to 30 sec.) with an audible crackling sound and then rose quickly as more aluminum surface was exposed. The panel should be removed just before this rise. The film from both panel sides was removed by gentle mechanical treatment under water.

Contrary to Lacombe and Beaujard's observation, the sealed films produced by boiling water were easily detached. In several tests the entire film from a side was detached in one piece; however, unsealed films broke into several pieces.

*Chemical Div., Aluminium Laboratories Ltd., Kingston, Ont., Canada

† "Quick Method for Electrolytic Polishing and Etching of Metallographic Specimens", by A. DeSy and H. Haemers, *Stahl und Eisen*, Vol. 61, 1941, p. 185 to 187.

‡ "A New Method of Detaching Anodic Oxide Films Formed on the Surface of Aluminum and Its Alloys", by P. Lacombe and L. Beaujard, *Metaux Corrosion-Usure*, Vol. 20, 1945, p. 43 to 47.

Epoxy Resins as Mounting Materials

*By R. O. QUINN and M. McGAWN**

The accurate mounting of small parts and thin delicate sections has always been a problem for the metallographer because mounting materials used in the past have required heat or pressure, or both, to harden them.

Much of the metallographic work done at this laboratory involves the sectioning of fabricated parts of light-gage sheet metal for microscopic and macroscopic examination. Since neither heat nor pressure is desirable for this work, casting resins of the chemical setting epoxy type were tried. The success with these materials has led to their use to replace almost all other mounting methods.

Casting resins are available which consist of two liquid components, a resin and an activator. Only simple mixing and casting techniques are necessary, and the mount hardens in a few hours

*Research and Technical Dept., American Can Co., Maywood, Ill.

Example of the Usefulness of the Plastic Is This Specimen Showing the Degree of Fit-Up in a Paint Can Cover

at room temperature. If higher temperatures can be tolerated, the time can be shortened to a matter of minutes. Separately, the two liquids are stable at room temperature but, once mixed, should be used immediately. After the casting has hardened, the usual metallographic procedures of grinding and polishing can be applied. The plastic, when hardened, is highly resistant to all etches and solvents which the metallographer might use.

No attempt has been made to explore fully the entire array of commercially available resins. The following have been found to be generally acceptable for metallographic work:

Bakelite C-8 Resin BR-18774
Shell Epon No. 828
Armstrong C-4 Adhesive.

The nonplasticizing activator we use is diethylenetriamine, which is applied as 1 part by weight activator to 10 parts of resin.

No doubt, many uses can be found for these resins other than the preparation of the final mount. For example, in the sectioning of thin or delicate materials, the plastic may be poured on or into the part to obtain a firm back-up so that no distortion is produced in the piece during cutting. The accompanying halftone illustrates the use of the plastic for this purpose. The plastic supported section is in turn recast in a short length of bakelite tubing to form the final mount.

Certain additives to the mixed liquid resin will improve its use as a mounting medium. Carbon black, which may be added to obtain a jet black mount, also helps dissipate the heat due to grinding. Various colors can be produced by the use of dyes. In particular, a red dye such as Safranin-O will cause the mounting medium to appear dark in the final photographic prints. Carbide particles may also be inserted to inhibit the rounding of the specimen during polishing.

New Use for Bi and Te?

*By TOM BISHOP**

It was over 100 years ago that Peltier discovered the heating or cooling effect, quite apart from the usual resistance heating, when an electric current flows through the junction between two different metals. Whether the junction becomes hotter or colder depends upon the direction of current flow. For various practical reasons little use has been made of the effect. Recent work in the research laboratories of the General Electric Co., Ltd., Wembley, England, has now produced a semiconductor thermojunction which gives a cooling effect of nearly 50° F.

Interest in the problem revived with the development of silicon and germanium transistors. The thermo-electric effect with semiconductors is about 100 times larger than with metals. This is not sufficient in itself to provide a practicable cooling effect because the Peltier cooling is usually much less than the heating effect in the junction due to its own resistance. When this resistance is made small by the use of short, thick junctions, too much heat is conducted from the hot to the cold end of the cooling unit and the cooling effect is lost. The present objective is to find semiconductor materials having high electrical and low thermal conductivity which make large cooling effects possible.

A recent demonstration before the Royal Society in London showed a unit employing bismuth and a bismuth-tellurium compound which could freeze miniature ice cubes in a small metal tray. It is too early to say that this is the forerunner of new types of refrigerator units, or to quote figures for the efficiency of the system. At present this is certainly much less than the efficiency of conventional refrigerators.

Research is to continue and further developments are expected. One possibility is that sources of low-grade waste heat might be used with thermojunction generators to provide the low-voltage high-current supply required to operate the cooling junctions. The same factors which control efficient thermo-electric cooling apply also to efficient thermo-electric generators. The successful development of these to make use of waste heat or solar energy might well provide useful sources of electric power for a variety of applications.

*Editor, *Metal Treatment and Drop Forging*, London, England.

Brittle Failure of Steel Structures

Theory, Practice, Future Prospects

*By M. E. SHANK**

A great volume of recent experiments on brittle fracture – some on large pieces of steel – is summarized. Theory has advanced to where the plastic work, the modulus of elasticity and the size of crack can be correlated to the stress required for a catastrophic crack. Some ideas useful to designers and fabricators are outlined.

IN TWO previous *Metal Progress* articles in September and October 1954 the history of brittle failure of steel structures, and the factors of importance to this type of accident, were discussed. Three conditions may combine: First is low temperature. Second is the presence of a notch (introducing tri-axial stress) due to defects such as welding cracks or voids, or cracks left from punching or shearing operations. Third is high strain rate, or impact loading, which however is not necessary for the initiation of brittle failure.

This final article will attempt to set forth briefly some of the important theoretical and experimental developments in the field of inquiry, along with some views on present engineering design and fabrication practice and the future possibilities. A complete review cannot be attempted. It should also be stated at the outset that not all of the researchers in the field are in full agreement; what is presented here is, therefore, from the author's point of view.

Metallographic and Crystallographic Features – Brittle or cleavage failure may occur in any ferritic iron or steel. It can occur in iron of the very highest purity. Cleavage failure occurs also

*Associate Professor of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge.

in some other body-centered cubic metals, and in certain of the hexagonal close-packed metals, but they will not be discussed in this article. Cleavage failure is not known to occur in such face-centered cubic metals as pure gold, silver, copper or aluminum*, even at temperatures approaching absolute zero and in the presence of notches. Indeed, commercial austenitic steels are immune to brittle failure.

Slip in iron, with attendant plastic deformation, occurs in pencil fashion along planes containing the (111) direction. The actual "planes" on which this slip occurs are irregular and wavy, and are not specific crystallographic planes. Cleavage, on the other hand, occurs by separation without macro-plastic deformation on the (100) or cube face. This is shown in Fig. 1. A very graphic demonstration of this has been given by Parker[1] and his associates, in mild steel tested in tension at room temperature and at liquid air. These samples were sectioned, polished, and immersed in dilute nitric acid, which produced etch pits in the individual crystals. The sides of the pits were parallel with the cleavage faces of the individual crystals or therefore roughly at 45° to planes on which slip had occurred. Figure 2 shows the fracture of the specimen tested at room temperature; there is considerable plastic deformation, and the fracture surfaces are inclined obliquely to the sides of the etch pits. Figure 3 shows the fracture at liquid air temperature; here cleavage failure has occurred, no plactic deformation is visible, and the fracture lines are parallel to the sides of the etch pits.

Another important feature of brittle failure in polycrystalline ferritic steels is that the high-speed crack, which may travel up to 6000 ft. per sec. or more, runs in a discontinuous rather than smooth fashion. It is obvious that if each failed crystal is to cleave on a (100) face, the crack must change direction as it goes from one crystal to the next. Thus, cleavage starts independently in several neighboring grains. The resulting discontinuous cracks are then connected by plastic deformation at the grain boundaries. This implies that one should be able to observe discontinuous cracks adjacent to or ahead of the main fracture in steel that has failed in a brittle manner. This has been done by Jaffe[2]. See Fig. 4.

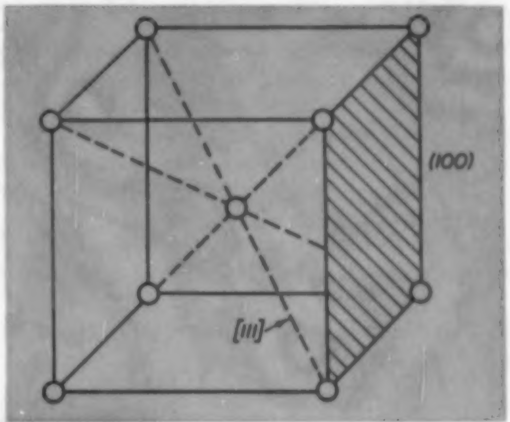
The surface of a brittle failure appears totally lacking in plastic deformation. See Fig. 5. In spite of this it can be shown by X-rays that some plastic deformation does occur. In annealed or hot rolled steel, X-ray diffraction spots are sharp. Plastic deformation causes diffuseness of these spots, and the *amount* of cold work can be estimated by the degree of diffuseness. The *depth* can be determined by etching away the fractured surface until the diffraction pattern is once again sharp. Felbeck and Orowan[3] have found the work of plastic distortion on a brittle fracture surface to be about 2×10^6 ergs per sq.cm., or roughly 6 in-lb. per sq.in. Estimates of other workers yield figures of a similar order of magnitude. They also found the depth of the cold worked layer to be somewhat less than 0.5 mm. As will later be shown, the work of plastic distortion is of considerable importance.

Tri-Axiality of Stress – The earliest workers to investigate brittle failure used impact loadings. This supported the opinion, fairly widespread even to recent years, that brittle fracture in steel resulted from loads applied at rather "high" speed, even though it was known that if a specimen contained a sharp, deep notch, brittle failure could then be induced by slow bending or slow tension. A Mesnager[4], making use of this observation in 1906, developed the theory of tri-axial tension in notch brittleness. His paper did not receive wide notice, and Ludwik in 1923 developed a similar theory.[5, 6]

Let us state, in simplest terms, the effect of a notch or sharp crack in a plate. If a uniform stress below the elastic limit is imposed on the plate in a direction perpendicular (axial direction) to the crack, a comparatively high stress in the same direction will exist just behind the root of the crack. This is diagrammed in Fig. 6. Moreover, in the region of the crack root the state of stress will be bi-axial. However, just behind the crack root in the uncracked metal, and a short distance from it, the stress will be of average value. If plastic flow is to occur at the crack root, there must be lateral contraction of the material at that place in order to preserve constant volume of material. (Constancy of volume is a necessary requirement of plastic flow.) Opposing this lateral contraction is the large amount of material, stressed to a lower value, behind the root of the crack (to the right in Fig. 6). This will induce a state of tri-axial stress, the third stress being perpendicular to the plane of the plate and tending to contract the material laterally at the root of the notch. The third stress is thus transverse tension. At this place it is a

*This statement does not apply to many alloys of these metals. For instance, evidence is beginning to accumulate that high-speed brittle cracks, similar in many respects to those found in steel, can occur in high-strength, precipitation hardened aluminum alloys.

Fig. 1 – Schematic Diagram of a Body-Centered Cubic Iron Crystal. The hatched (100) or cube face is the face on which brittle cleavage occurs. The (111) direction is direction of any cube diagonal, along which slip takes place



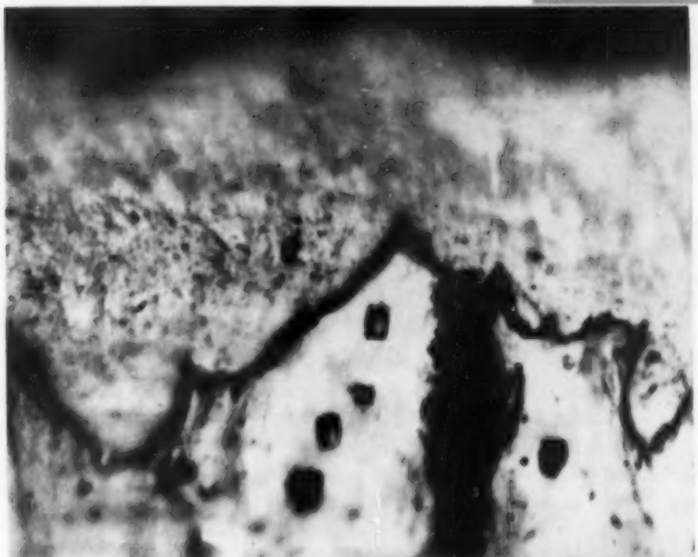


Fig. 2 – Shear Fracture in Steel. Fracture surfaces at room temperature are at approximately 45° to cube (100) faces as shown by etch pits. There is considerable plastic deformation. 1500 ×. (From Parker, Reference 1)

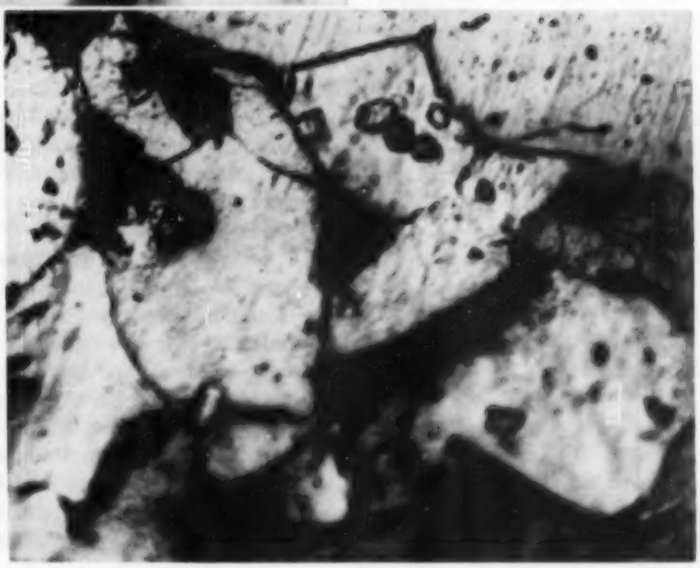


Fig. 3 – Cleavage Fracture in Steel. Fracture surfaces at liquid-air temperature are parallel to cube (100) faces as shown by etch pits. No evidence of plastic deformation. 1500 ×. (From Parker, Reference 1)

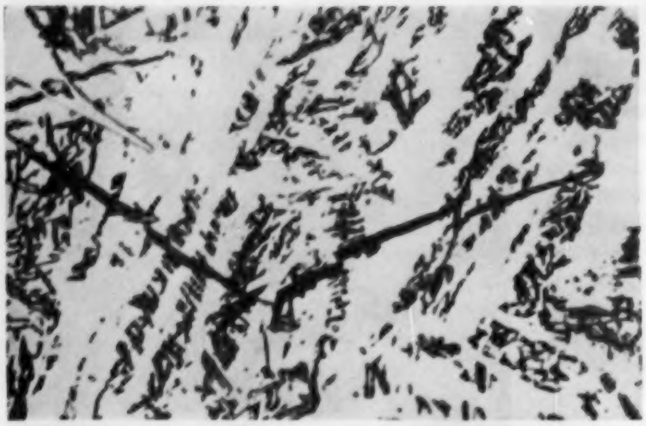
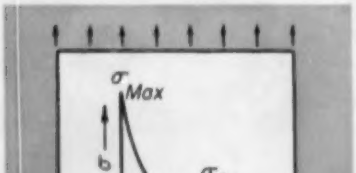


Fig. 4 – Discontinuous Cracks in a Steel Casting Which Failed in a Brittle Manner. 1500 ×. (From L. D. Jaffe, Reference 2)

Fig. 5 – Fragment of a Fractured Drum. The surface appears to lack macro-plastic deformation, but X-ray diffraction techniques show plastic work in a thin layer on the fractured surface

Fig. 6 – Sketch of Axial Stresses in a Plate Containing a Notch. The axial stress will be very high at the root of the notch and low in the material behind the notch. When plastic flow occurs, a third stress will arise at the crack root in a direction perpendicular to the plane of the plate



maximum at the center of the plate and must be zero on the faces of the plate. Another consequence is that the axial stress at the root of the crack will build up beyond the uni-axial yield stress Y of the material to some value Y_n before flow can occur. This is the basis of *plastic constraint* (as opposed to elastic stress concentration). The ratio of Y_n to Y is known as the "constraint factor".

Until recent years it had been believed that if the notch was of correct depth and sharp-ended, the stress at the root and the constraint factor would rise to infinity. However, in 1945 it was shown by Orowan, Nye and Cairns[7] that the maximum constraint factor is approximately 3. The proof of this is based on an adaptation of Hencky's classical plasticity solution[8] of the stress distribution in the indentation of a plate by a circular punch. While this proof applies to a circular specimen with a circumferential notch, it had been shown by Prandtl[9] in 1923 that the maximum constraint factor is approximately the same for a notch in a flat plate. From the foregoing it is evident that

if a sharp crack is present in a stressed plate, the stress at the crack root must rise to about three times the normal uni-axial yield stress of the material before plastic flow will occur.

Concept of Brittle Strength – In the Ludwik-Mesnager theory of tri-axiality, the reduction of fracture strain was explained. Ludwik also introduced the concept of "characteristic stress-strain curve of fracture". However, the conspicuous difference between fibrous and cleavage fractures was not explained. In 1936 Davidenkov[10] attempted to extend the theory so as to explain this difference, and was among the first to recognize the existence of fundamentally different fracture mechanisms. He therefore suggested there should be *two* characteristic stress-strain curves of fracture, one for brittle failure and another for ductile failure. It has since turned out that ductile fracture does not occur at values of a tensile stress which are dependent only on values of the preceding plastic strain. According to the geometry of the specimen and the types of notches present, ductile fracture can occur at widely different values of the tensile stress for the same amounts of plastic strain. This was shown by McAdam and Mebs[13] in 1943. However, there is much evidence to support the concept of a characteristic *brittle* fracture curve for ferritic materials.

Davidenkov and Wittman[11] in 1937 partly explained the phenomenon of transition temperature by means of the Ludwik theory. They drew a logical qualitative picture using the concept of "brittle strength". They were not aware, however, of the limiting value of plastic constraint at the tip of a sharp notch. As before noted, this factor was taken into account by Orowan [7, 12] in 1945. The resulting picture is shown in Fig. 7. Here brittle strength B, yield strength Y, and three times the yield strength 3Y (that is, the flow stress in the presence of a notch) are sketched as functions of temperature. It is experimentally *known* that yield strength rises with decreasing temperature. It is *assumed* that the brittle strength will also rise with decreasing temperature, but not at so steep a gradient.

Figure 7 indicates that above the temperature T_2, at which the curves of brittle strength and of 3Y intersect, the material concerned will be fully ductile, with or without the presence of a notch. Below temperature T_1, however, where the brittle strength intersects the yield strength, the material will always fracture in a brittle manner. The region between these two temperatures is the "notch-brittle zone", wherein the material will behave in a ductile fashion in the presence of uni-axial stress, but if a notch is present, it will fail in a brittle manner before the stress of 3Y with attendent plastic flow can be reached. In practice, however, the transition from full ductility to full brittleness occurs in a narrow temperature zone rather than at a particular temperature. This is true, for instance, in the Charpy impact test.

There was no experimental proof of the existence of a characteristic curve of brittle strength until October 1951, when Eldin and Collins[14] published an important piece of research on the fracture and yield stress of A.I.S.I. 1020 steel at temperatures near absolute zero (12° K.) and up to 185° K. Specimens were tested in uni-axial tension (no notches). From 12 to 61.5° K. all specimens exhibited typically brittle fracture, with no reduction in area, and the strength dropped steadily and linearly as the temperature was increased. At 61.5° K. a sharp transition occurred. While below this temperature there was no reduction of area before fracture, above 61.5° K. the reduction of area increased rapidly as the testing temperature was increased, and a yield stress, as well as a subsequent fracture stress, could be measured. Some of their data are plotted in Fig. 8. All of the fractures were brittle in appearance to 100° K. At 104° K. the broken section contained a dark fibrous (ductile) dot at its center. Above 185° K. all of the fractures were ductile.

While much research yet remains to be done on the brittle strength of steels, this work of Eldin and Collins presents strong evidence to support the current hypotheses.

Strain Rate – The yield strength of most metals is not particularly sensitive to strain rate. In typical nonferrous metals, for instance, increasing the strain rate by several orders of magnitude will increase the yield strength by perhaps 15 or 20%. In low-carbon steels, however, a corresponding increase in strain rate will increase the stress at which yield occurs by 100 or 200%. This explains the effect of impact in inducing brittle failure. If the strain rate is such that the brittle strength of the metal is exceeded, brittle failure will result.

It should be noted also that if a crack is traveling rapidly, the strain rate at the tip of the crack will be very high, even though the external load application is static in nature. The foregoing implies that the brittle strength has a relatively small dependence on velocity. This appears to be true.

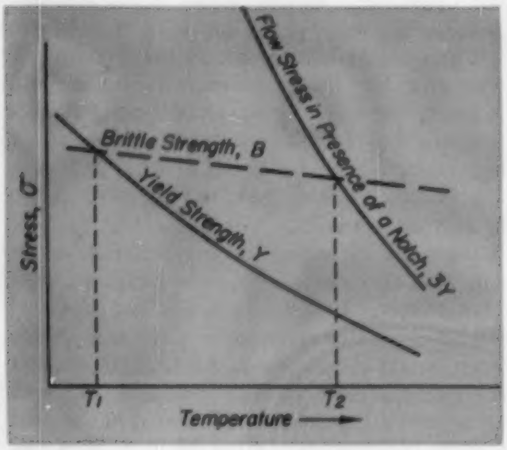


Fig. 7 – Plot of Stress Vs. Temperature to Explain Transition Temperature in a Notch-Brittle Material. Above T_2 the material is fully ductile. Below T_1 it is fully brittle. The region between T_1 and T_2 is the transition range

Some Recent Research Work

During and after World War II many brittle fracture tests were made on large specimens of steel plate. Great difficulties were encountered in duplicating service fractures – a problem not fully overcome even today – which are almost always of a cleavage type from their very inception. Moreover, service failures often occur at relatively low average stresses.

In laboratory tests of plate it was the usual practice to provide a sharp notch or saw cut so as to start a brittle failure under tensile loading. In this way the fractures were initiated at quite high stresses, and often with a region of ductile failure which preceded the initiation of a brittle crack. This resulting brittle crack then traveled across the plate. However, only the starting stress, and not the driving stress, could be measured.

In an attempt to overcome these difficulties, T. S. Robertson [15, 16, 17] devised a method from which he hoped to determine the stress required to make a crack "run". In effect, he placed a saw cut at the edge of the plate, and initiated a brittle crack at low temperature by a wedging impact force which opened up the crack. The specimen had a temperature gradient across it, the notch end being cold, and the opposite end being warm. All the while the specimen was in tension in a direction perpendicular to the notch. The crack traveled across the plate, and was arrested at some particular point. Beyond this point, and above the particular temperature at this point, only ductile failure could take place in the plate.

Robertson repeated these experiments with different values of tensile stress in the plate, but with similar temperature gradient. He then plotted the stress against the arresting temperature, and for most of his steels the results were of the type sketched in Fig. 9. It will be noted that there appears to be a sharply defined temperature limit above which brittle crack propagation cannot take place. Robertson also experimented with plates of uniform temperature and verified that the limiting temperatures for crack propagation were the same as in plates with a temperature gradient.

In addition to Robertson's excellent experi-

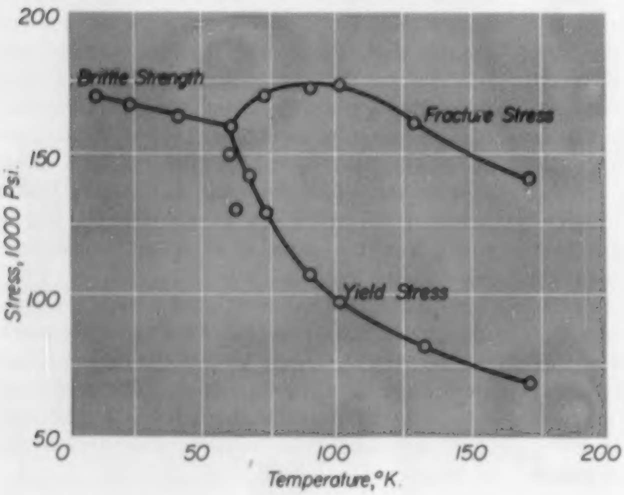


Fig. 8 – Tests on A.I.S.I. 1020 Steel Showing Evidence of a Brittle Strength Curve. Below 61.5° K. no reduction of area occurred. Above this temperature yielding took place. (From Eldin and Collins, Reference 14)

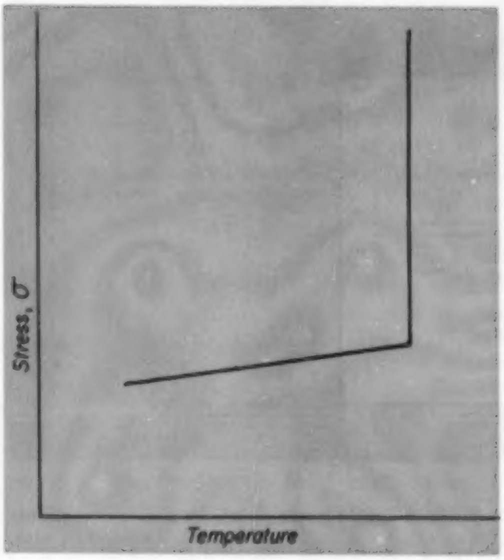


Fig. 9 – Schematic Presentation of Robertson's Data Showing a Plot of Stress Vs. Temperature. Above the temperature limit defined by the vertical line, a brittle crack does not propagate. (References 15, 16 and 17)

mental work, Feeley and associates[18] did some very fine work in which fracture was initiated by a wedge driven by a bullet into a crack or notch in a stressed plate. However, in any tests in which fracture has been initiated by wedge penetration or by any type of wedging action, the interpretation of results is far more complex than it appeared at first.

The effect of a penetrating wedge is roughly equivalent to an additional local tensile stress. This additional stress can start the propagation of the crack. It does this by making the crack so long, and its rate of propagation so fast, that the applied tension on the plate can take over when the wedge effect has disappeared. However, there seems to be no way of estimating the crack length at the moment when its propagation is taken over by the applied tensile stress. Contrary to earlier hopes, the wedge indentation does not start off the crack propagation in a single instant before the length of the crack has increased significantly. The effect of the wedge and that of the applied stress are inextricably mixed up in the mechanism of starting the crack. A discussion by E. Orowan of the factors involved in the initiation of brittle fracture by wedge penetration will shortly be published.[19]

Independent of these difficulties, however, is Robertson's measurement of the temperature above which a crack cannot run in brittle fashion. Above this limit the velocity of the running crack, aided by such tri-axiality as may exist at the crack tip, cannot raise the yield stress to the level of the brittle strength. Therefore, only yielding can occur. The temperatures which Robertson has determined agree roughly with measurements of transition temperatures.

Energy Criteria for Brittle Failure – In 1920 Griffith[20] proposed his theory, based on energy criteria, for the fracture of fully brittle materials (such as glass which manifests no plastic behavior). This theory aids in an understanding of the present problem even though it cannot be applied directly to materials which exhibit plastic flow, even in such a small degree as does steel when it fails in brittle fashion. As pointed out before, the *surface* layer of a brittle fracture in steel always undergoes *some* plastic deformation.

In attempting to explain the strength of brittle materials, Griffith postulated the existence of tiny cracks which he idealized as ellipses. See Fig. 10. Assume such a crack in a thin plate of unit thickness; it is small in comparison to the width and length of the plate. The crack length is the major axis of the ellipse and is equal to 2C. The plate is stressed at an average value σ and in a direction perpendicular to the major axis of the crack. Let α be the surface energy per unit area of the material. Since the area of crack surface is 4C, the energy required to create the crack is all surface energy, and has the value

$$W_s = 4C\,\alpha$$

No other energy is required, since the material in question cannot behave plastically. The crack can arise only by drawing elastic energy from its *immediate* surroundings. The density of elastic energy is proportional to $\sigma^2 \div 2E$ if the crack is small compared to the plate. Furthermore, the region from which the crack can draw energy can be shown to be proportional to C^2, C being the half-the-crack length. For a thin plate it is also proportional to π. Thus, the available energy to keep the crack growing is

$$W_e = \frac{\pi\,\sigma^2\,C^2}{2E}$$

If the crack increases in length, the elastic energy of the plate increases because the average applied stress remains constant while the plate undergoes deformation as the crack lengthens. Griffith's criterion for propagation of the crack is, then, that for a differential increase dc in crack length, the increased elastic energy dW_e must be just sufficient to supply the increased surface energy dW_s of the extended crack. Differ-

entiating the above two expressions with respect to C and equating results in the above expressions

$$\sigma = \sqrt{\frac{2E\alpha}{\pi C}} \approx \sqrt{\frac{E\alpha}{C}}^{*}$$

When the stress given by this equation is reached, the crack will be unstable and will run catastrophically. It will be noted that the stress for failure is inversely proportional to the square root of the crack length. Quadrupling the length of crack, for instance, halves the stress for crack propagation. If the plate is thick compared with the crack length, the constants of the expression are slightly different.

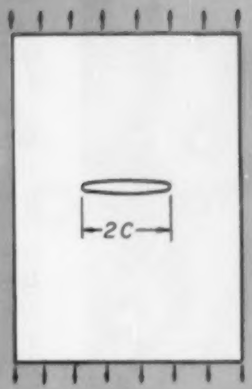


Fig. 10 – Idealized Eliptical Crack in a Plate of Fully Brittle Material. The plate is stressed at some average value σ and the length of the crack is 2C

The Griffith equation has in fact been shown to be the controlling one in the strength of glass and the theory adequately explains its mechanical behavior. Moreover, cracks have been observed in glass, the lengths of which correlate well with the equation. (It should be noted that a surface crack of length C will have the same effect as an interior crack of 2C.)

In the light of the foregoing, Orowan conceived a modified Griffith equation which would apply to the brittle failure of steels, and take account of the plastic layer on the fractured surface. In the following discussion the present author is indebted to him for permission to summarize information which will shortly appear as a series of papers dealing extensively with the subject.[3, 21, 22] Orowan has included in the expression for the surface energy of the crack the plastic work p required to deform the thin, cold worked layer on the fractured surface. As before noted, this plastic work has been measured, and is about 2×10^6 ergs per sq.cm. Thus, the surface energy of the fractured surface will now be $W_s = 4C(\alpha + p)$ and the final expression for the stress at which brittle failure can take place (if other conditions are correct) is

$$\sigma \approx \sqrt{\frac{E(\alpha + p)}{C}}$$

The value of p is about 1000 times greater than that of the surface energy α (which for most metals is of the order of 10^3 ergs per sq.cm.). Consequently, the surface energy can be dropped from the expression, giving finally

$$\sigma \approx \sqrt{\frac{Ep}{C}}$$

*Symbol ≈ means "approximately equal to".

Felbeck and Orowan[3] performed experiments to verify this expression. They used plates which had been slotted on the edge with a saw, and then cooled in dry ice. With the plate unstressed, a wedge was driven into the saw cut to initiate a sharp cleavage crack. The specimen was then placed in a testing machine and stressed to failure. When the fracture stress was plotted against the crack length a smooth, hyperbolic curve resulted.

However, it was observed that the initial, artificial brittle crack failed to propagate in a brittle manner when fracture stress was reached. *Plastic* deformation first occurred and the crack propagated in a fibrous manner accompanied by considerable local reduction of the plate thickness. Following this the crack reconverted to cleavage running at high velocity. Apparently with the low rates of loading employed a cleavage crack cannot continue to propagate in brittle fashion.

Thus, the velocity effect is important in maintaining a running, brittle crack. Moreover, a considerable degree of tri-axiality is necessary in the fibrous crack that follows before it can be converted into a brittle crack. These experiments therefore measured an average stress higher than that given by the modified Griffith equation – namely, an average stress which is required for initiating the high-velocity crack by means of a condition of plastic constraint.

The last equation indicates that for a given crack length in a steel, brittle fracture can occur if a critical value of the average tensile strength is reached. Conversely, brittle fracture can occur at any average stress value if an existing crack is long enough. In addition to this, however, one of two conditions must be fulfilled: First, the

rate of stress application must be high enough to bring the yield stress of the material up to the brittle strength without the presence of tri-axiality. (This is represented by the case of a high-velocity running crack.) Second, considerable plastic deformation is induced at the tip of a crack, so that three times the yield stress exceeds the brittle strength, (Fig. 7). These two conditions may also occur in combination.

Thus, a state of tri-axial stress, and some rate of stress application – neither of which by itself is sufficient to cause brittle failure – may together permit its occurrence, provided also that

$$\sigma = \sqrt{\frac{Ep}{C}}$$

In most brittle failures that have occurred in service, the fracture is fully brittle from its very inception, with little or no evidence of macro-plastic deformation. Such fractures usually occur at perfectly static stresses, apparently of low average value. This has been duplicated in the laboratory under static conditions only if the specimen contained a weld. Experiments of this type were performed by Weck[23] in 1952, who found that thermal contraction stresses, if of sufficient severity, could produce spontaneous brittle fracture of welded assemblies without additional external stresses, providing the specimen contained a sharp notch. These thermal contraction stresses combined both the restraint of a heavy frame into which the specimen was welded, and the ordinary residual stresses resulting from a weld in the specimen itself. Weck's material had a gradual transition from tough to brittle in a notch bend test extending from + 30 to − 20° C., and the fractures from thermal contraction were produced when the metal was at about − 8° C., well within the transition range. Somewhat similar effects were noted by Greene.[24]

The foregoing does not imply, however, that *welds* must be present for the initiation of brittle failures in service. Numerous brittle failures have occurred in riveted structures. Nor is it implied that residual stresses are of prime importance in initiating brittle failure in welded structures. Many service brittle failures have also been known to start at design stress concentrations. These facts were pointed out in the two previous articles. It is therefore somewhat of a mystery how a rapidly moving crack, with no evidence of tri-axiality at its origin, is initiated in service under static stresses of low average value.

The question therefore arises, "Can brittle failures occur in service which are brittle from their very inception without the presence of a weld?" The question cannot now be answered with certainty. Failures in riveted structures were seldom if ever examined by observers who noted conditions at the origin of the fracture.*

Present Industrial Practice

Ideally speaking, two extreme alternatives are possible, either of which would totally prevent brittle failure of steel structures.

First would be to use a material which is totally immune to brittle failure. Utilization of austenitic stainless steel, or the substitution of some nonferrous metal with face-centered cubic crystal structure such as copper or aluminum for mild steel would accomplish this. Obviously, however, these materials are too expensive for such common use, both from the standpoint of lower allowable working stresses and of cost per pound. This solution becomes practical only for equipment operating at extremely low temperatures where ferritic steels are glasslike in their behavior and the slightest flaw in material or fabrication could cause disaster. Containers for liquid air or natural gas are examples.

The second, and extremely opposite, approach is to employ a good-quality ferritic material and fabricate it in such a manner as to insure complete absence of any flaws which could initiate brittle failure. This is an economically feasible course where the cost of materials is high compared to labor – a situation which does not exist in the United States. In some European countries, however, this is a practical procedure for which Izett steel is used. Izett steel is essentially an aluminum-killed low-carbon steel, made under carefully controlled chemical and physical specifications. It is quite tough for such a material; the A.S.M. Metals Handbook indicates that a keyhole-notch Charpy specimen will absorb 35 ft-lb. at − 40° F. The real secret of its successful

*This author recently talked to C. G. Lutts of the Boston Naval Shipyard metallurgy laboratory, who was the first to note the meaning of "chevron markings" in brittle failures in service. This was in connection with the failure of the Boston molasses tank, a riveted structure. At this date, 35 years later, he recalls generally that the regions of brittle fracture were preceded by areas of fibrous fracture with plastic flow. These plastically deformed areas were adjacent to the rivet holes, where failure apparently originated.

For a more complete description of this failure, see the author's "A Critical Survey of Brittle Failure in Carbon Plate Steel Structures Other Than Ships", Bulletin No. 17 of the Welding Research Council, January 1954, and Ship Structure Committee Report SS C 65.

use, however, is careful, high-quality workmanship and inspection which completely eliminated defects. All welds are also stress-relieved.

Use of metal totally immune from brittle failure, or fabrication of a structure completely free from flaws, are both unattainable ideals for most situations. The problems and the choices lie in the region between the two extremes. In the construction of bridges, pressure vessels and ships, both material and fabrication costs must be held to reasonable levels. The fabricator is free to choose among such variables as chemical composition and deoxidizing procedure of his material providing he can stay within the commercial limits of reasonably priced, tonnage steel. Moreover, in choosing among varying chemical compositions, he must pick a steel which has sufficient strength to carry a reasonable working stress. As a consequence, much of the burden for the prevention of brittle failure must be placed on good design – which will accomplish, among other things, elimination of stress concentrations – and on good workmanship to prevent flaws.

Inspection plays an important part as well, and here it might be noted that one recent failure was initiated by a weld inspection probe which had been poorly replaced. Thus, X-rays are coming into greater use for detection of welding flaws. The thoroughness of inspection deemed desirable is dependent upon economic considerations. Many companies spot check welds at random by radiography. One oil company, however, radiographs completely all vertical welded joints in storage tanks.

Some Thoughts for the Future

Much argument has centered on the proposal to use deoxidized steel. It is well known that, for steels which are generally similar, a fully killed steel will have a lower ductile-to-brittle transition temperature than a semikilled steel. Similarly, a semikilled steel has a lower transition range than a rimming steel. These distinctions are not clear cut; there is some overlap. However, the use of rimming steels in the past may have contributed to some brittle failures. Having this in mind, the American Bureau of Shipping established new specifications for structural ships for hulls in 1947, which in effect, exclude rimming steels in larger ships and require a fully killed steel in heavy plate. Experience with post-World-War II ships indicates that the use of killed plate is often desirable.

This substitution of one deoxidation practice for another is, however, not the cure-all for brittle failure, inasmuch as there are recent experiments which show that, aside from large alloy additions which are not economical under ordinary circumstances, there is a limit to the gains to be derived through changes in a steel's chemical composition. Data from the National Physical Laboratory in Great Britain[25] show that the transition temperatures for high-purity iron are not appreciably below those for ordinary ferritic steels.

Another question often raised concerns the relative merits of various tests for notch brittleness. All of these tests used in the United States (Charpy or Izod with V, keyhole or U-notches, tear tests, and so on, or the Schnadt test used in some parts of Europe) are consistent within themselves in that they generally rate a given group of materials in relatively the same order. None of them are absolute; their numerical results of foot-pounds of energy absorbed cannot be utilized directly in design.

A graphic demonstration of this is given comparing two Charpy specimens, geometrically similar, and differing only in size, tested at the same temperature and velocity of impact. Under the correct experimental conditions it will be found that when the smaller of the two specimens is fully or partially ductile, with high energy absorption, the larger one will be completely brittle with negligible energy absorption! Thus, it becomes impossible to project the results of any test directly to the behavior of a full-sized structure.

Moreover, this situation also indicates that the practice of figuring the energy absorbed per unit of cross-sectional area of the specimen is meaningless. Tests for notch brittleness are therefore of value only when correlated with experience derived from structures in service. Consequently, the American Society for Testing Materials' Standard A-300, which requires a minimum Charpy V-notch impact value of 15 ft-lb. at a specified service temperature (if such temperature is below -20° F.) is as good a guide as is available at the present time. Recent investigations of ship failures by M. L. Williams[26, 27] and of non-ship failures by the author[28] seem to lend validity to this type of specification. Certainly, however, the engineer is in need of better criteria for making design decisions.

In conclusion, it seems fair to state that the basic mechanics of brittle failure is now fairly well understood; better understood, in fact, than many other fracture phenomena. The great remaining problem is the exact mechanism whereby such failure is initiated in service. Certainly

further investigation is needed on this point.

Much developmental research will be needed. New, rather than traditional, avenues of approach may have to be tried. The real difficulty at the present time is to acquaint the designer, the metallurgist, and the engineer with the available facts so that these facts may be utilized in designing, welding, fabricating and steelmaking. Application and utilization of this available knowledge will be in itself no small task.

References

1. "A Study of the Tension Test", by E. R. Parker, H. E. Davis and A. E. Flanigan, *Proceedings* of the American Society for Testing Materials, Vol. 46, 1946, p. 1159.

2. "Discontinuous Crack Propagation – Further Studies", by L. D. Jaffe, E. L. Reed and H. C. Mann, *Transactions* of the American Institute of Mining and Metallurgical Engineers, Vol. 185, 1949, p. 683.

3. "Experiments on Brittle Fracture of Steel Plates", by D. K. Felbeck and E. Orowan, Technical Report No. 1, Office of Naval Research, Contract N5ori 07870 (Submitted for publication to *Welding Journal*).

4. International Association for Testing Materials, Brussels Congress, 1906, by A. Mesnager, *Rapport Non-officiele*, No. A6f, p. 1-16.

5. "Ueber Kerbwirkungen bei Flusseisen", by P. Ludwik and R. Scheu, *Stahl und Eisen*, Vol. 43, 1923, p. 999.

6. "Ueber die Bedeutung der Elastizitatsgrenze, Bruchdehnung und Kerbzahigkeit fur den Konstrukteur", by P. Ludwik, *Zeitschrift fur Metallkunde*, Vol. 16, 1924, p. 207.

7. Theoretical Research Report No. 16/45, by E. Orowan, J. F. Nye and W. J. Cairns, Armament Research Dept. MOS, London, 1945.

8. "Ueber einige statisch bestimmte Falle des Gleichgewichts in plastischen Korpen", by H. Hencky, *Zeitschrift fur Angewandte Mathematik und Mechanik*, Vol. 3, 1923, p. 241.

9. "Anwendungsbeispiele zu einem Henckyschen Satz uber das plastisch Gleichgewicht", by L. Prandtl, *Zeitschrift fur Angewandte Mathematik und Mechanik*, Vol. 3, 1923, p. 401.

10. "Dinamicheskaya ispytania metallov", by N. N. Davidenkov, Moscow, 1936.

11. Physical-Technical Institute of Leningrad, FE 4/93, 1937, by N. N. Davidenkov and F. Wittman.

12. "Notch Brittleness and Strength of Metals", by E. Orowan, *Transactions* of the Institution of Engineering and Shipbuilding in Scotland, 1945, p. 165.

13. "An Investigation of the Technical Cohesive Strength of Metals", by D. J. McAdam and R. W. Mebs, *Metals Technology*, Vol. 19, T. P. 1615, American Institute of Mining and Metallurgical Engineers, August 1943.

14. "Fracture and Yield Stress of 1020 Steel at Low Temperature", by A. S. Eldin and S. C. Collins, *Journal of Applied Physics*, Vol. 22, 1951, p. 1296.

15. "The Propagation of Brittle Fracture", by T. S. Robertson and D. leM. Hunt, *Journal of the West of Scotland Iron and Steel Institute*, Vol. 60, 1952-53, p. 259.

16. "Propagation of Brittle Fracture in Steel", By T. S. Robertson, *Journal of the Iron and Steel Institute*, Vol. 175, 1953, p. 361.

17. "Brittle Fracture of Mild Steel", by T. S. Robertson, *Engineering*, 1951, p. 445.

18. "Report on Brittle Fracture Studies", by F. J. Feeley, D. Hrtko, S. R. Kleepe and M. S. Northup, *Welding Journal Research Supplement*, Vol. 33, February 1954, p. 99-s.

19. "The Initiation of Brittle Fracture by Wedge Penetration", by E. Orowan, Technical Report No. 5, Office of Naval Research Contract N5ori-07870. (Submitted to *Welding Journal* for Publication.)

20. "The Phenomena of Rupture and Flow in Solids", by A. A. Griffith, *Philosophical Transactions of the Royal Society*, Vol. A221, 1920, p. 163. See also his "The Theory of Rupture", *Proceedings* of the First International Congress of Applied Mechanics, Delft, p. 55.

21. "Energy Criteria of Fracture", by E. Orowan, Technical Report No. 3, Office of Naval Research, Contract N5ori-07870. (Submitted for publication in *Welding Journal.*) See also "The Condition of High-Velocity Ductile Fracture", Technical Report No. 4, Office of Naval Research, Contract N5ori-07870. (Submitted for publication in *Welding Journal.*)

22. "Tension Impact Tests With Circumferentially Notched Specimens", by L. Engler and E. Orowan, Technical Report No. 2, Office of Naval Research, Contract N5ori-07870. (Submitted for publication in *Welding Journal.*)

23. "Experiments on Brittle Fracture of Steel – Resulting From Welding Stresses", by R. Weck, *Welding Research*, Vol. 6, August 1952, p. 70-s.

24. "Evaluation of Effect of Residual Stresses", by T. W. Greene, *Welding Journal Research Supplement*, Vol. 28, 1949, p. 193-s.

25. "Tensile and Impact Properties of High-Purity Iron-Carbon-Manganese Alloys of Low Carbon Content", by N. P. Allen, W. P. Rees, B. E. Hopkins and H. R. Tipler, *Journal of the Iron and Steel Institute*, Vol. 174, 1953, p. 108.

26. "Investigation of Fractured Steel Plates Removed From Welded Ships", by M. L. Williams, M. R. Myerson, G. L. Kluge and L. R. Dale, Ship Structure Committee Report, Serial NBS-3, June 1951.

27. "Examinations and Tests of Fractured Steel Plates Removed From Welded Ships", by M. L. Williams, Ship Structure Committee Report, Serial NBS-4, April 1953.

28. "A Critical Survey of Brittle Failure in Carbon Plate Steel Structures Other Than Ships", by M. E. Shank, Bulletin No. 17 of the Welding Research Council, January 1954. (Also Ship Structure Committee Report SS C 65.)

Correspondence . . .

More on the Measurement of Case Depth

PATERSON, N. J.

The correspondence item "A Job for A.S.M." by Joseph J. Warga, chief metallurgist of Steel Products Engineering Co., in *Metal Progress* for February 1955, p. 118, presents the timely and important problem of establishing a standard for measuring carburized case depth.

A very large percentage of gears, particularly aircraft gears, are of the carburized type, yet in many years of experience I have not seen a print or specification that defined how the depth of case was to be measured.

Our practice has been to work to the effective case depth, defined as the point where the hardness range is Rockwell C-53 to 56, which is approximately in the center of the transition zone on a cross section of an as-carburized (soft) specimen, polished and etched.

In our gas carburizing methods, we have established time cycles for various case depths with interrupted diffusion periods whereby we obtain a wide demarcation line or transition zone, and periodically include two flat test bars 8 in. long with a regular carburizing load. We then make a carbon analysis of each 0.005-in. layer of case of one as-carburized bar. The second test bar is hardened and tempered for hardness measurements at increments of 0.005 in. This enables us to plot a carbon-versus-hardness gradient graph.

The writer supports Mr. Warga's views that some standardized method for measurement of effective case depth should be established, and that American Society for Metals should sponsor such a standard.* In answer to Mr. Warga's closing words, "What to do about it", appoint a committee to study the problem and recommend a standard method of measuring case depth.

WILLIAM VON SEGGERN
Watson-Flagg Machine Co.

*EDITOR'S COMMENT: Years ago this Society had committees whose jobs were to prepare "recommended practices" for publication in the Metals Handbook. This practice has been discontinued and probably will not be resumed, at least in the near future. The A.S.M. has never formulated or issued standards, nor is there much possibility it ever will.

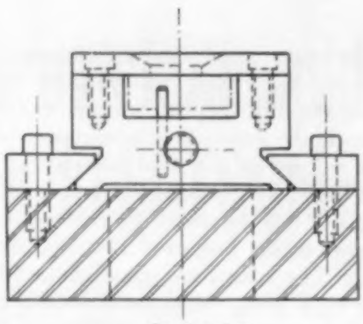
Taylor Lyman, who directs current activities on the Metals Handbook, intends to formulate a committee to deal with the measurement of case depth. The most likely approach to the problem of measuring case depth will be for the committee to describe the frequently used methods in the best current commercial practice. The committee will be encouraged to recommend one method over another, either for specific purposes or in general, and it will be almost required to compare the advantages and disadvantages of the methods. However, it will not be required to decide on one method as the "standard" method.

MONTREAL, CANADA

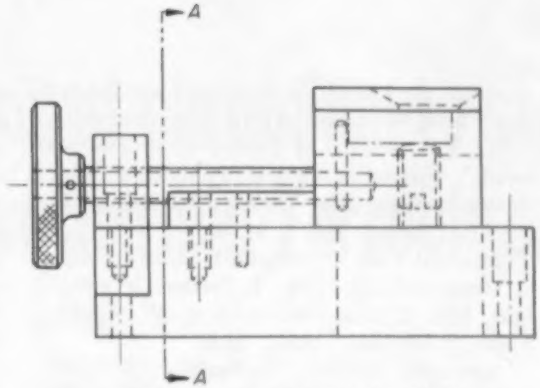
Our method of measuring the depth of carburized case may be of interest to readers of Mr. Warga's letter who are also asking "How can we measure effective case depth?"

We prepare a hardness-depth curve on the cross section of the quenched test piece. The case depth is defined as the depth to any arbitrary hardness – in our work Vickers 500.

The method is to cut and rough polish the hardened test piece, which may be 1 in. square. The sample is then clamped face up against the underside of a thin plate with an opening in it to expose an edge and part of the polished face through the opening. (The drawing on the opposite page gives two views of the clamping device, which we call Penetrascope Hardness Checker.) The clamp is mounted on a calibrated screw which permits traversing of the specimen. The whole clamp assembly is placed in position in a Vickers-type hardness tester that can be used with a load of 5 kg. The impressions vary in size from about 0.115 mm. at a hardness of



Section AA



Penetrascope Hardness Checker Used at Dominion Engineering Works, Ltd., for Determining Depth of Carburized Case

702 to 0.136 mm. at 502; the hardness readings are taken at intervals of about 0.010 in. Estimation of case depth can be made by inspection of the readings without actually drawing a curve.

It requires about ½ hr. to complete the entire test, including reheating, quenching and sectioning of the test piece, this being quite acceptable for deep case batch-type operation. We have found that the test can be performed by an intelligent workman and that it gives reproducible results free from any personal factor.

The test can of course be used with any grade of steel and we have found it of particular value with a 3½% nickel carburizing steel. The hardened fracture in this case is useless as a measure of case depth and the microstructure, while usable for the purpose, is difficult to read and can be misleading.

A. H. Lewis
Chief Metallurgist
Dominion Engineering Works, Ltd.

No Slight Intended

Detroit

We note in your February 1955 issue an article entitled "Electrostatic Finishing of Appliances". In reading this article, one would get the impression that Ransburg Electro-Coating Corp. had built the entire finishing system, less the conveyer. The facts are, this is a complete Mahon Finishing System, planned, engineered, built and installed by the R. C. Mahon Co. This includes the paint storage and circulating system.

The Ransburg Corp. installed the electrostatic spray equipment in one of the three Mahon spray booths (top picture on p. 84 and p. 86). All other equipment shown is Mahon equipment.

Frederick R. Anderson
President
Anderson, Inc.

Three-Inch Book Shelf on Quality Control

Steubenville, Ohio

A question that is asked frequently enough that it may be of general interest to A.S.M. members is, "What books would you recommend for more details on quality control than are in the Metals Handbook article?" There are so many good books that a complete answer to this question soon exceeds both the shelf space and money available to any except a professional librarian.

The following three-inch shelf of books on

quality control has been found to cover the field rather well for such a modest expenditure:

"A.S.T.M. Manual of Quality Control of Materials", Special Technical Publication 15-C, American Society for Testing Materials, Philadelphia (January 1951), $1.75.

"Practical Uses of Statistical Quality Control in Metal Industries", W. J. Youden, Irving W. Burr, John W. Hood and John W. W. Sullivan, A.S.M., Cleveland (1954), $1.50.

"Automatic Control Terminology", American Society of Mechanical Engineers, 29 West 39th Street, New York (1954), $1.00.

"Some Rapid Approximate Statistical Procedures", Frank Wilcoxon, American Cyanamid Co., Stamford, Conn. (July 1949).

"Facts From Figures", M. J. Moroney, Penguin Books, Baltimore 1, Md. (1951), $.80.

"An Outline of Statistical Methods", Herbert Arkin and Raymond R. Colton, Barnes & Noble, New York, $1.50.

"Tables for Statisticians", Herbert Arkin and Raymond R. Colton, Barnes & Noble, New York, $1.00.

"Fundamentals of Statistics", J. B. Scarborough and R. W. Wagner, Ginn and Co., Boston, $2.60.

FRANK G. NORRIS
Metallurgical Engineer
Wheeling Steel Corp.

No Shortage of Industrial Diamonds

(But no Abundance Either)

NEW YORK, N.Y.

The trend of some of the articles on sintered carbide grinding with diamond wheels or other media that appear from time to time in trade magazines gives great concern to the Industrial Diamond Assoc. of America, which has responsibility for the welfare of the industrial diamond industry in this country.

In face of the many statements made in good faith by so many persons of evident authority, the denial that there is a shortage of industrial diamonds might be difficult to believe. However, this is the fact, and we feel it is our duty to supply you with the explanation, inasmuch as the December 1954 issue of *Metal Progress* printed an extensive article, "Grinding Cemented Carbides", by Arthur H. Allen. The article is the latest of those that are unintentionally crystallizing an erroneous impression in the minds of the public.

The information that follows has been supplied to many (who then changed their views) and it was recently supplied in practically the same terms to the Senate Subcommittee investigating self-sufficiency in critical materials.

So that you may evaluate the source of the main points of this statement, we cite the origin and purposes of the Industrial Diamond Assoc. of America. The association was organized nine years ago by a group of industry leaders as a result of their own experience and that of War Production Board officials, during World War II. It was needed for the coordination of such forward-looking activities as a trade association might properly concern itself within the interests of the group and in the public interest, which includes maintenance of a healthy condition in an essential industry. Ever since, this association has been called upon by the various branches of Government and by American industry in general for advice and cooperation.

At the outset of "Korea", with huge government contracts to be distributed to manufacturers of automotive, aeronautical and other important military materials, each manufacturer took immediate steps to insure for himself an abundant supply of equipment and tools. Avalanches of unusual orders fell on the producers of diamond tools – manufacturers were duplicating their orders almost wherever orders were being taken. In their turn, the manufacturers of diamond tools (mostly grinding wheels) rushed to obtain supplies of diamond powder and of the bort type of industrial diamond.

The National Production Authority's Miscellaneous Metals & Minerals Div. was besieged from all sides with pleas for assistance in obtaining crushing bort and powder. It was difficult, if not impossible, to evaluate the actual requirements. So, although there appeared to be a critical shortage, there was no shortage.

The executive manager of this association, together with its various members, when called for conference or by their own initiative, were able to convince the Government and others that if it could know where to locate all of the raw commodity, and influence its acquisition and sale, and that if those who used diamond grinding wheels in industry were prohibited from ordering more than their reasonable advance requirements, the shortage bubble would burst.

The National Production Authority by its Order M-102 sponsored by the N.P.A. Miscellaneous Metals & Minerals Div., and Order M-103

(Continued on p. 170)

Improve ladle additions of chromium to steel with ELECTROMET Exothermic Ferrochrome

LOW CARBON PICKUP

ELECTROMET Exothermic Ferrochrome 8, which has a 12 to 1 chromium-to-carbon ratio, gives a carbon pickup of 0.08% for each per cent of chromium added. ELECTROMET's new Exothermic Ferrochrome 5, having a 20 to 1 chromium-to-carbon ratio, gives only about 0.05% carbon pickup for each per cent of chromium added.

HIGH CHROME RECOVERY

About 92% of the chromium is recovered regularly. This provides close control of chromium specifications in the finished steel with a minimum loss of alloy.

FAST SOLUBILITY

ELECTROMET exothermic ferrochrome generates the right amount of heat to melt the alloy quickly and prevent chilling the metal in the ladle.

Other advantages of ELECTROMET'S Exothermic Ferrochrome:

High ignition temperature (above 750 Deg. F.) gives maximum protection against fire hazard during storage.

For convenient, easy handling the alloy is packed in cans, or in strong, flameproof and moisture-proof bags. Cans or bags are shipped on pallets at customer option. Each pallet holds 60 cans or 80 bags.

No weighing is necessary since each can or bag holds exactly 25 lb. of contained chromium. Just count the cans or bags to obtain the weight desired.

FREE TECHNICAL ASSISTANCE . . .
in the use of the material is furnished by ELECTROMET's experienced field representatives. Further information will be gladly furnished on request. Please contact one of the offices listed below.

ELECTRO METALLURGICAL COMPANY

A Division of Union Carbide and Carbon Corporation

30 East 42nd Street UCC New York 17, N. Y.

OFFICES: Birmingham • Chicago • Cleveland • Detroit
Houston • Los Angeles • New York • Pittsburgh • San Francisco

In Canada: Electro Metallurgical Company, Division of Union Carbide Canada Limited, Welland, Ontario

Electromet

TRADE-MARK

Ferro-Alloys and Metals

Personal Mention

Anton deSales Brasunas

An important step in the development of the "A.S.M. of Tomorrow" (*Metal Progress,* December 1954, p. 80) is the establishment of the "Metals Engineering Institute". To implement this extensive home-study program Anton Brasunas has been appointed to the newly created position of director of educational activities for A.S.M.

Dr. Brasunas has an exceptional background in educational, scientific and practical aspects of metallurgy. He has a B.S. degree in chemical engineering from Antioch College, a Master's in metallurgy from Ohio State University, and a Ph.D. from Massachusetts Institute of Technology. As a research engineer at Battelle Memorial Institute (1943-47) he worked on high-temperature problems; as a metallurgist at Oak Ridge National Laboratory (1950-52) he tackled the unique metallurgical problems of nuclear reactors; and, most recently, as associate professor at University of Tennessee he has developed an enthusiastic interest in metallurgical education at all levels. He is currently vice-chairman of the Oak Ridge Chapter A.S.M., and has served in various official capacities for the National Association of Corrosion Engineers and the American Society for Engineering Education.

Dr. Brasunas's first assignment will be the organization and production of more than 40 metals engineering courses. The Society is to be congratulated on securing the services of such a competent instructor and organizer.

W. H. Eisenman, *Secretary*
American Society for Metals

James P. Hontas, headquarters staff metallurgist who has been working with Metals Handbook committees for the past six months, has been promoted to district manager of *Metal Progress* in the Philadelphia-New Jersey area. Prior to his appointment to the A.S.M. staff last year, Mr. Hontas was employed by Goodyear Aircraft Corp., Cleveland Graphite Bronze Co., and Clark Controller Co. He holds degrees in engineering from Colorado School of Mines and in business administration from Fenn College.

Ernest George Kendall, formerly research engineer with Titanium Metal Corp. of America, Henderson, Nev., has eccepted an International Nickel Co. of Canada fellowship at the University of Kentucky for the degree of doctor of engineering in physical metallurgy.

Sub-Editor Wanted

Metal Progress needs a man who can take charge initially of digests and correspondence pages and articles in limited portion of editorial field appropriate to his experience. Degree in metallurgical engineering (or its equivalent) and some plant experience almost essential for future advancement. Ability and desire to write direct, simple, colloquial American essential; editorial experience desirable but not necessary. Salary in proportion to education, metallurgical and editorial experience. Send account of qualifications to M. R. Hyslop (Confidential), Managing Editor, *Metal Progress,* 7301 Euclid Ave., Cleveland 3, Ohio.

Clyde Williams

The honorary degree of doctor of laws was conferred upon Clyde Williams, president and director of Battelle Memorial Institute, Columbus, Ohio, by Ohio's Marietta College at its recent Founder's Day convocation. In bestowing the degree, Dr. Williams was cited for his belief that "material and spiritual achievements cannot be separated from each other" and for his conviction that "industrial research is the activating force behind our nation's progress". He was also noted for the many special contributions to his country in time of war, and his practical application of his faith in the ability of free men to solve their problems. Dr. Williams also holds honorary doctorates from Case Institute of Technology, University of Utah, Michigan College of Mining and Technology, and Ohio State University. His business, academic, and governmental affiliations are many, as are his special wartime (World War II) committee memberships and chairmanships. He was recipient of the Presidential Citation and Medal for Merit for wartime direction of research activities. Dr. Williams is the author or co-author of 117 published articles and bulletins. He holds memberships in 28 technical and professional societies, and is a past president of the American Institute of Mining and Metallurgical Engineers.

Harry Barnett has been appointed vice-president and general manager of Donald Inspection Limited of Montreal and Toronto.

Welding Copper

Inert gas shielded metal arc welding of new copper shell for rebuilt tower.

SAVES 38% in materials and labor for joining

Some time ago, the Tennessee Eastman Company, Kingsport, Tennessee, a Revere customer, began to rebuild some of its copper stills or fractioning towers, which previously would have been silver-brazed. Revere's welding specialists were called in to see whether or not welding would be superior. Demonstrations were made to Tennessee Eastman engineers and shop personnel, with the result that welding was adopted. Actual experience in the shop shows a saving of 38% in materials and labor for joining, and a better job in every way. The welding method used is the inert gas shielded metal arc process.

Reconstruction of the towers was made to reduce the number of flanges. At the same time Tennessee Eastman changed from the flange joint tray construction to the inserted tray type and incidentally, reduced the number of gaskets with their accompanying maintenance problems. The trays are salvaged by shearing off the bolt hole circle and folding up the edges. The towers are some 45' high, 6' to 10' in diameter, with a tray or bubble cap plate at specified intervals. Tennessee Eastman plans to rebuild several towers a year in this economical way.

It will pay you as it did Tennessee Eastman to look into welding as a modern method of joining copper. Remember Revere is fully experienced in the most modern and efficient methods, and will collaborate with you on their application.

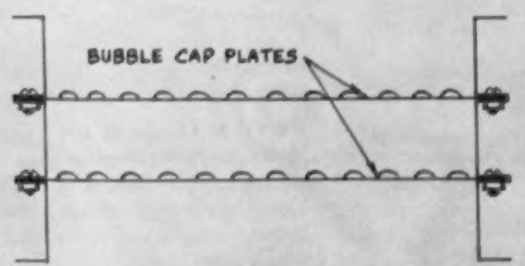
REVERE

COPPER AND BRASS INCORPORATED

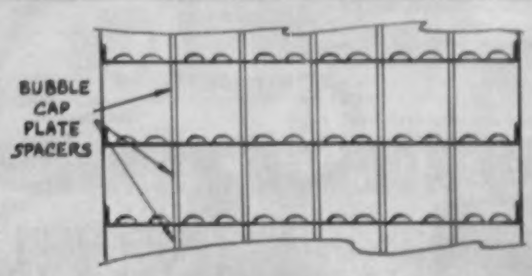
Founded by Paul Revere in 1801

230 Park Avenue, New York 17, N. Y.

Mills: Baltimore, Md.; Chicago and Clinton, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Rome, N. Y. Sales Offices in Principal Cities, Distributors Everywhere.



Section through old tower, showing bubble cap plates held in bolted flange.



Section through new welded tower. Bubble cap plates have had bolt holes sheared off, edges turned up. They are held in place by spacer rods.

Personals . . .

W. J. Brigham, formerly district manager of the Cincinnati office of the Timken Roller Bearing Co., is now district manager of the Detroit office. A graduate of the University of Michigan, Mr. Brigham started with Timken in 1940, after serving five years with the Chrysler Corp. Prior to his Cincinnati assignment, he was a sales engineer in the company's Chicago office. **John J. McGrann**, district manager of the steel division's Houston, Texas, office, has assumed Mr. Brigham's post at Cincinnati. A graduate of Ohio State University, Mr. McGrann joined the Timken Roller Bearing Co. in 1945, after serving in the U. S. Army for five years. Succeeding Mr. McGrann as Houston district manager is **Ralph Preston**, formerly a sales engineer in the Houston office, who has been with the company since 1949 after graduating from the University of Kentucky. After serving two years in the U. S. Army, he returned to the company as a metallurgist, then became a sales trainee before he was assigned to the Houston office as a sales engineer. **Edwin E. Lightfoot**, a 1952 University of Michigan graduate and a recent sales trainee, has been assigned to the Houston office as a sales engineer.

Emmett A. Smith has been appointed chief engineer in the electrode division of the Lincoln Electric Co., Cleveland. Mr. Smith graduated from Ohio State University in 1928 as an electrical engineer and immediately joined the Lincoln engineering department. He was assistant chief engineer prior to this appointment.

H. George De Young has been appointed executive vice-president of Atlas Steels Limited, Welland, Ont., after having acted in that capacity for some time. After joining the Atlas company in 1951 as works manager, Mr. De Young was named vice-president of operations in May 1952, and appointed to the board of directors in March 1954. Immediately prior to his first Atlas appointment, he was works manager of Treadwell Engineering Co., Easton, Pa. Mr. De Young graduated from the United States Naval Academy at Annapolis in 1931, but resigned his commission in the Navy and went to work for Midvale Co., Philadelphia. As superintendent of the shell department making armor-piercing projectiles, he received an award from the U. S. Government for research and development. He was made works engineer for Midvale in 1947, resigning in 1949 to go with Treadwell Engineering.

John E. Srawley has joined Arwood Precision Casting Corp., Brooklyn, N. Y., in the capacity of standards engineer. Mr. Srawley holds the degree of B. S. with first class honors in engineering metallurgy from the University of London, England. Except for a period of service as a pilot with the Royal Air Force, he has been a metallurgist since 1938, and prior to joining Arwood had been assistant director of research with the Meehanite Corp., New Rochelle, N. Y.

Robert W. Stoddard, formerly vice-president of Wyman-Gordon Co., Worcester, Mass., is now president of the company.

C. J. McGowan has been appointed sales engineer for the standard steel works division of Baldwin-Lima-Hamilton Corp. in western Pennsylvania and West Virginia, working out of the Pittsburgh office. He was formerly associated with Kropp Forge Co. in its Chicago sales territory.

Personals . . .

Wallace B. Leyda has been appointed chief metallurgist of Ohio Seamless Tube Division of Copperweld Steel Co., Shelby, Ohio. Before joining Ohio Seamless, Mr. Leyda held a similar position with Northern Indiana Brass Co., Elkhart, Ind.

H. O. Klinke has joined the Taylor-Winfield Corp., Warren, Ohio, as a sales engineer.

Richard W. Sievert is president of the recently incorporated firm of Milwaukee Fabrication, Inc., Milwaukee, Wis.

Edwin S. Tankins is now employed in the metallurgical engineering section of the steam division, Westinghouse Electric Corp., South Philadelphia, Pa., and in addition is attending the University of Pennsylvania, working for a M. S. degree under the Westinghouse educational program.

William E. Mahin has resigned as technical director of Vanadium Corp. of America at the research center in Cambridge, Ohio, to accept the position of vice-president and director of research for the Hunter Engineering Co., Riverside, Calif.

Julius J. Kirchhof, formerly executive vice-president of the Franklin Balmar Corp., Baltimore, was recently elected president. He has been a member of the organization since 1937.

Wells E. Ellis, who received his master of science degree from the University of Illinois, has been appointed assistant lubrication engineer at the Timken Roller Bearing Co., Canton, Ohio. Starting with the company in 1948, Mr. Ellis served as a research metallurgist until his recent promotion.

Charles M. Ruprecht, president of Electro-Alloys Division of American Brake Shoe Co. since 1953, has been named executive vice-president of National Bearing Division. Mr. Ruprecht joined the company as a sales apprentice in 1946, and was made sales manager of the Electro-Alloys Division in 1950, moving up to vice-president and president. **Paul L. McCulloch, Jr.**, sales manager of the Electro-Alloys Division since 1953, succeeds Mr. Ruprecht as division president. Mr. McCulloch joined the company as a trainee in 1945 and joined the Electro-Alloys Division as a sales engineer in 1947.

A. F. ("Charlie") Davis was recently honored by the Lincoln Electric Co., Cleveland, as one of its oldest employees in point of service. Mr. Davis received a service pin in recognition of his 40 years of continuous service with the company, which he serves as vice-president and secretary.

Harold W. Hanes has been appointed research metallographer for the Vanadium Corp. of America at its new research center in Cambridge, Ohio. Until recently Mr. Hanes had been metallographer at Ford Motor Co., Cincinnati, Ohio.

Albert G. Haynes has accepted the position of assistant chief engineer, Oscar C. Rixson Co., Franklin Park, Ill. He was formerly with the Buell Mfg. Co., Chicago.

Personals . . .

Charles O. Smith, formerly with Aluminum Research Laboratories, Aluminum Co. of America, New Kensington, Pa., is now service engineer, engineering services division, E. I. du Pont de Nemours and Co., Inc., Wilmington, Del.

William J. Doelker has been appointed chief metallurgist of Globe Industries, Inc., Dayton, Ohio.

Karl E. Beu has joined the staff of the laboratory division of Goodyear Atomic Corp. near Portsmouth, Ohio, as supervisor of physical measurements department. He had been previously employed by Phillips Petroleum Co., research department, in the chemical physics section, Bartlesville, Okla., and for the past six years as senior physicist in charge of X-ray diffraction research in the laboratory division of General Motors Corp., Detroit.

William J. Buechling, former chief metallurgist, has been appointed one of the assistant general superintendents of Copperweld Steel Co., Warren, Ohio. A graduate of Carnegie Institute of Technology in 1926, Mr. Buechling has been at Copperweld since 1940. Prior to that time he was with the central alloy district of Republic Steel Corp.

Kenneth A. DeLonge has been placed in charge of the iron and nonferrous castings section of the development and research division of the International Nickel Co., Inc., New York. Mr. DeLonge graduated from Michigan State College as a mechanical engineer in 1936. He joined International Nickel in June 1937 as a member of the cast iron section of the company's research laboratory at Bayonne, N. J., and in March 1940 was transferred to the development and research division in New York as a specialist on Ni-Hard.

R. K. Rawlins, who has been on the Chicago sales staff of Lindberg Engineering Co. for several years, has been appointed district manager with offices in Dallas and will direct sales activities in the Texas-Louisiana area. He succeeds **William A. Hammer**, who has resigned to join Dominy Heat Treating Corp., Dallas.

Wilson A. Holland has been appointed to the staff of the gaseous diffusion plant at Oak Ridge, Tenn., an atomic energy installation operated by Carbide and Carbon Chemicals Co., a division of Union Carbide and Carbon Corp.

Edgar W. Husemann, former assistant chief metallurgist, has been named chief metallurgist of Copperweld Steel Co., Warren, Ohio. Mr. Husemann, a 30-year steel veteran, is a graduate of the Illinois Institute of Technology and has been with Copperweld since 1941. Prior to that time he taught chemistry at Lewis Institute in Chicago, and for 14 years was a metallurgist with the South Chicago district of Republic Steel Corp.

W. J. Lohmeyer, Jr. has been promoted to district manager of the Pittsburgh territory of Latrobe Steel Co. Mr. Lohmeyer is a graduate of the University of Pittsburgh and has been associated with Latrobe Steel Co. in a sales capacity since 1945.

Personals . . .

Byron Campbell ⊕ was recently appointed vice-president and director of engineering of Allen Electric and Equipment Co., Kalamazoo, Mich. Mr. Campbell, a graduate of Case Institute of Technology in electrical engineering, did post-graduate work at Johns Hopkins University, and then joined the Timken Roller Bearing Co., Canton, Ohio, as development engineer in charge of engine and physical laboratories. In 1940 he became development engineer for the Glenn L. Martin Co., Baltimore, and later was transferred to Omaha as chief of laboratories. In 1945, Mr. Campbell joined Harry Ferguson, Inc., Detroit, as chief of laboratories, and in 1951 was promoted to executive engineer.

Earl J. Hagan ⊕ is now chief metallurgist of Aircraft-Marine Products, Inc., Harrisburg, Pa.

Vincent E. Lysaght ⊕ has been appointed general sales manager of the American Chain & Cable Co., Inc., with headquarters in New York City. He was formerly divisional manager of the Helicoid, Campbell Machine and Wilson divisions of American Chain & Cable. Mr. Lysaght is a graduate of Massachusetts Institute of Technology and author of the book "Indentation Hardness Testing".

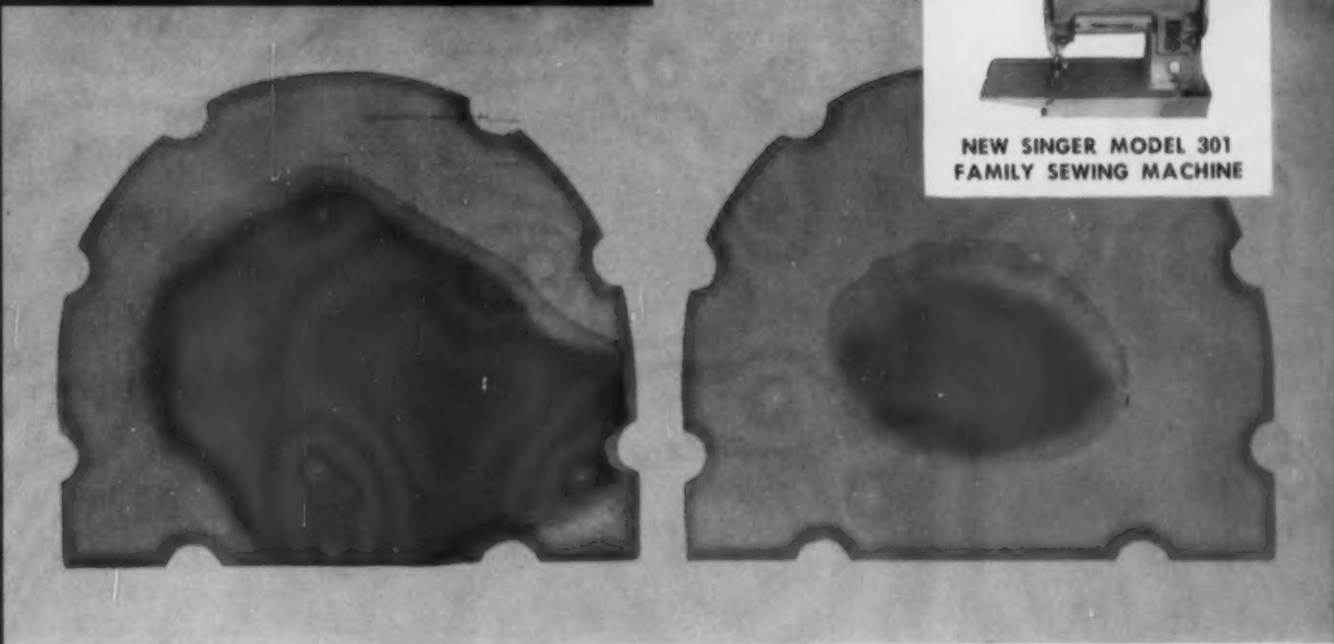
Charles C. Mathews ⊕ has joined the technical division of Superior Tube Co., Norristown, Pa., and is assigned to the metallurgical laboratory. He was formerly employed at Joseph T. Ryerson & Son, Philadelphia, as a sales engineer, and prior to that at Bethlehem Steel Co., Bethlehem, Pa. He was graduated from Pennsylvania State University in 1942 with a bachelor of science degree in metallurgical engineering.

Stanley W. Moulton ⊕ has joined the engineering staff of Hitchiner Mfg. Co., Inc., Milford, N. H. Mr. Moulton has specialized in the production of investment castings since leaving Massachusetts Institute of Technology in 1950. Since that time he has been connected with the Midwest Precision Castings Co., Cleveland, and for the past year was chief engineer at Midwest.

Herbert J. Arnold ⊕ was recently appointed supervisor of stainless, bar, wire and billet sales for Crucible Steel Co. of America, Pittsburgh. Mr. Arnold began his career with Crucible in 1945 as a metallurgical sales engineer. Previously, he had been associated with Goodyear Tire and Rubber Co., Thompson Products, Inc., and the aviation division of Packard Motor Car Co. in various engineering capacities. In 1948 Mr. Arnold was named general supervisor of the metallurgical department at Crucible's Sanderson-Halcomb Works in Syracuse, N. Y. Four years later he was appointed supervisor of stainless sales for Crucible's Cleveland branch, a position he held until his recent promotion. He is a graduate of Ohio State University, holding a bachelor of metallurgical engineering degree.

L. E. Simon ⊕ has been promoted from chief metallurgist to chief process engineer of Electro-Motive Div., General Motors Corp., La Grange, Ill.

MODERN HEAT PROCESSING



OLD METHOD hardened too much of part area, causing warpage. **G-E INDUCTION HEATER** cuts heat-treated area 75%—warpage reduced.

PROBLEM:

Old method of hardening SINGER Sewing Machine parts caused warpage, doubled costs

SOLUTION:

G-E Induction Heater "Pinpoints" Heat Reduces Costly Warping of Treated Parts

The Singer Manufacturing Company, Elizabethport, N. J. was having trouble hardening parts for its sewing machines. Only a small area in the high-carbon steel item needed hardening. But too large an area was being heated with the fuel-fired method used. This resulted in warpage. And subsequent straightening of the part was required. Result—high labor costs and production slowdowns.

A G-E 5-KW INDUCTION HEATER was selected because of its greater selectivity in heating the required area. Now the affected area is "zeroed in" with induction heat. The heated area is reduced 75%, thus greatly reducing the costly warpage. As a result, at least twice as many of these parts per day are being produced with the new 5-kw induction heater for the new SINGER 301 family Sewing Machine.

THE OVER-ALL IMPROVEMENT was explained by the manager of the heat-treating department of The Singer Manufacturing Company: "This method of heating has reduced the area affected by high temperatures to one-quarter of that obtained by the former method. With the G-E induction heater, the warpage is greatly reduced and straightening is no longer a problem. This improvement has produced more uniformly graduated marking on the finished parts and helped us to cut cost."

GENERAL ELECTRIC

G-E 5-KW INDUCTION HEATER with built-in variable output transformer, handles jobs formerly requiring larger heaters.

For application assistance, contact your nearest G-E Apparatus Sales Office or send coupon for free bulletin GEC-920B.

General Electric Company
Apparatus Sales Division, Section E722-1
Schenectady 5, New York

Name ....
Position ....
Company ....
City .... State ....

Personals . . .

F. J. Walls, in charge of the Detroit technical field section of the development and research division of the International Nickel Co., Inc., delivered the Charles Edgar Hoyt lecture of the American Foundrymen's Society during its convention in Houston, Tex., last month. A past president of A.F.S., Mr. Walls was selected because of his continued interest in improving the quality level of foundry education, his long service to the organization and his contributions to the foundry industry as a whole. He has been associated with International Nickel since 1934.

Edsel E. Bishop, formerly metallurgist at the Duquesne, Pa., works of the United States Steel Corp., was recently appointed metallurgist and manager of product development at the Ambridge, Pa., works of Wyckoff Steel Co.

Philip T. Stroup was recently appointed assistant director of research at the Aluminum Research Laboratories of Aluminum Co. of America in New Kensington, Pa. Dr. Stroup received his A.B. and A.M. degrees in chemistry from the University of Indiana and his Ph.D. degree in physical chemistry from the University of Wisconsin in 1929. He joined the Aluminum Research Laboratories at that time in the physical chemistry division. He was transferred to the metallurgical division in 1936 and was promoted to chief of the process metallurgy division in 1942.

Harry N. Hill, who has been assistant chief of the Aluminum Research Laboratories' engineering design division, Aluminum Co. of America, New Kensington, Pa., since 1944, is now chief of the division. Mr. Hill received his B.S. degree in civil engineering from the University of Pittsburgh in 1927, and received his M.S. degree in engineering mechanics from Carnegie Institute of Technology night school in 1939. He joined Alcoa in 1927, where he was employed in the physical testing division of the research laboratories.

Scouller L. Weaver has been promoted to district manager of the Buffalo territory of Latrobe Steel Co. Mr. Weaver graduated from Pennsylvania State University with a bachelor of science degree in metallurgical engineering. Following various sales engineering capacities and a period of service with the U. S. Navy during World War II, he joined Latrobe Steel Co. as a sales engineer attached to the Chicago office. He later was promoted to district sales manager of the Pittsburgh office.

A. Craig Hood and **George E. Clauser** have joined the technical division of Superior Tube Co., Norristown, Pa., and have been assigned to the metallurgical laboratory. Mr. Hood formerly was employed at Union Twist Drill Co., Athol, Mass., and at Midvale Co., Philadelphia. He was graduated from Massachusetts Institute of Technology in 1950. Mr. Clauser was formerly employed at the AGT Division of Westinghouse Electric Corp., and is a graduate of Lehigh University, class of 1953.


FORGED TO GIVE CARS
STRONG BODIES
• YOU CAN'T JUDGE A ROLL'S STRENGTH BY ITS FINISH.
In the Midvale roll above, both finish and strength are important . . . a hard surface for wear, a smooth surface to give a fine finish on auto body steel, and toughness for durability in cold rolling service.
Midvale forges rolls that have both. A half-century of steel-making experience goes into every roll . . . experience in casting ingots, in forging to develop its strength, in heat treating to give it desired properties where needed, and in machining to give it the surface finish.
Of major importance are the tests given the forging at different stages . . . tests to check on composition, structure, hardness, strength and dimensional accuracy.
The same is true of every Midvale product . . . rolls for steel or paper mills . . . forging and alloy castings for heavy machinery, reduction gears, hydraulic presses, turbine machinery, press cylinders and high pressure vessels.
You name the purpose . . . we'll supply the roll . . . of hardened and ground alloy or stainless steel.
THE MIDVALE COMPANY-Nicetown, Philadelphia 40, Pa.
Offices: New York, Chicago, Pittsburgh, Washington, Cleveland, San Francisco
MIDVALE
FORGINGS, ROLLS, RINGS, CORROSION AND HEAT RESISTING CASTINGS

Personals . . .

Lawrence F. Boland, sales manager of the Beryllium Corp., Reading, Pa., since 1952, has been named to the newly created office of vice-president in charge of sales. Mr. Boland, who became associated with the firm in 1935, previously served as a sales correspondent, production control chief, and production manager. The board of directors at the same meeting re-elected **Matthew J. Donachie** president of Beryllium Corp.

William H. Wills, Jr., formerly metallurgist with Universal-Cyclops Steel Corp., Titusville, Pa., is now employed in the tubular products division, Babcock & Wilcox Co., Beaver Falls, Pa.

R. F. Bunshah, formerly on the staff of the research laboratory of Carnegie Institute of Technology, is now associate engineering scientist with the research division of New York University.

D. L. Douglass holds the St. Joseph Lead Co. fellowship at Pennsylvania State University and is working toward his Ph.D. in metallurgy. Mr. Douglass was formerly research metallurgist in the atomic energy division, Savannah River plant, E. I. du Pont de Nemours & Co., Inc., Augusta, Ga.

Frank St. Vincent, formerly service engineer for Vanadium Corp. of America in the Pittsburgh district, is now manager of sales and service for Globe Metallurgical Corp., Beverly, Ohio.

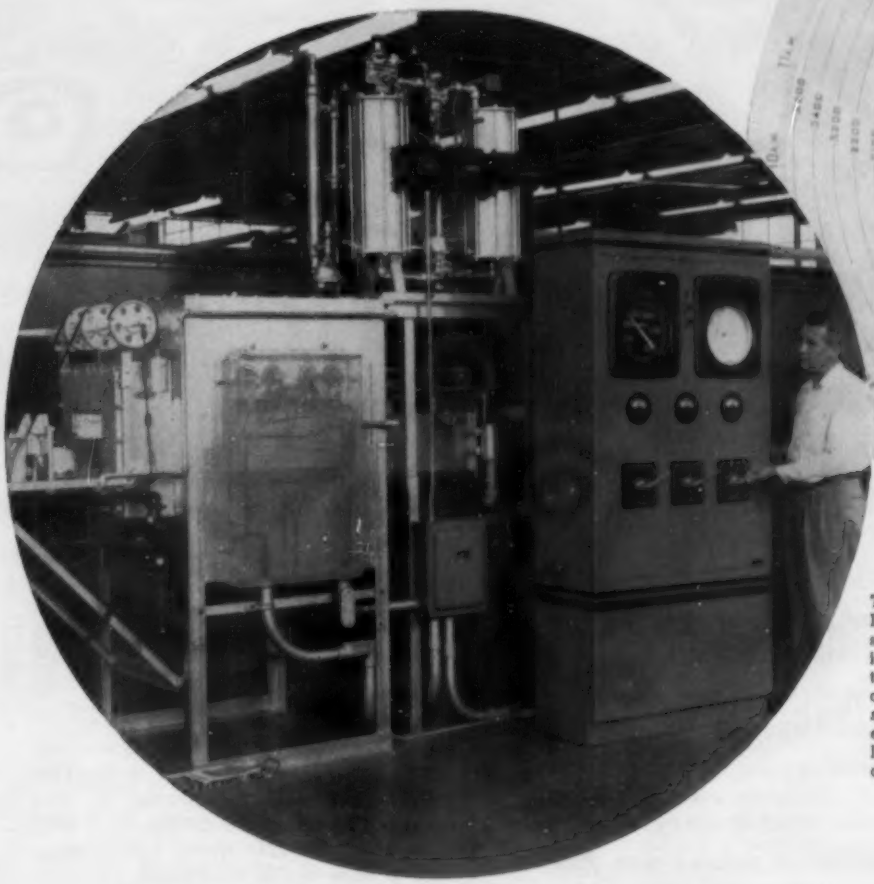
John D. Berwick Jr., formerly chief metallurgist in the metals division of Olin-Mathieson Chemical Corp., New Haven, Conn., has joined Seymour Mfg. Co., Seymour, Conn., as assistant to the works manager.

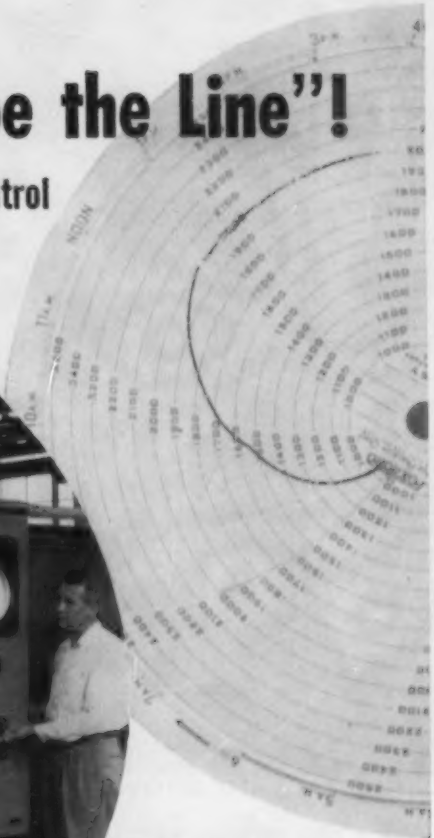
Gerald J. Lubin, formerly metallurgist for the Electric Auto-Lite Co., Toledo, Ohio, is now research analyst for Menasco Mfg. Co., Burbank, Calif.

R. G. Coleman, formerly research metallurgist for Massey-Harris-Ferguson, Ltd., Toronto, has been transferred to the Detroit branch to become chief of materials laboratory and materials engineer.

Furnace Temperatures "Toe the Line"!

. . . under new Foxboro Electric Proportional Control





This typical chart from Foxboro M/81b Controller shows how furnace (left) is brought up to temperature and precisely held at control point *without overshoot*. Installation is on electric furnace hardening high-precision, small machined parts.

Heat treating temperatures stay right on the control line when the new Foxboro M/81b Electric Proportional Controller handles furnace heat input. This fast-acting Controller assures the furnace a "balanced diet" of B.T.U.'s despite upsets, load changes, furnace lags, or ambient temperatures.

Control action is simple — effective. The M/81b senses any tendency of temperature to move away from pre-set control point . . . automatically varies ratio of heat "time-on" to "time-off" depending on changes in furnace loading. This *Proportional-set Average-position Controller* eliminates over- and under-shoot . . . maintains unusually uniform furnace conditions.

For top performance from your electrically heated or fuel-fired muffle-type furnace . . . new or modernized . . . investigate Foxboro Electric Proportional Control. Write for Bulletin 4-11.

THE FOXBORO COMPANY, 526 NEPONSET AVENUE, FOXBORO, MASSACHUSETTS, U. S. A.

FOXBORO
REG. U. S. PAT. OFF.

Electric Proportional Controllers

FACTORIES IN THE UNITED STATES, CANADA, AND ENGLAND

Personals . . .

Harvey D. Ross recently resigned as plant metallurgist of Temco Aircraft Corp., Dallas, Tex., to accept a position as senior metallurgist, Trentwood, Wash., rolling mill, Kaiser Aluminum & Chemical Corp.

Howard E. Pellett, formerly chief metallurgist of Metal Control Laboratories, Huntington Park, Calif., has been named secretary-treasurer of Pasadena Steel Treating Co., Pasadena, Calif.

Donald Lee Byrne recently left the research department of Allegeny Ludlum Steel Corp., Dunkirk, N. Y., to serve two years in the U. S. Army.

Robert E. Boni, formerly research metallurgical engineer for the Timken Roller Bearing Co., Canton, Ohio, after obtaining the degree of Ph.D. from Carnegie Institute of Technology, is presently in the U. S. Army doing metallurgical research for the Interior Ballistics Laboratory of the Ballistics Research Laboratory at Aberdeen Proving Ground, Md., as a private.

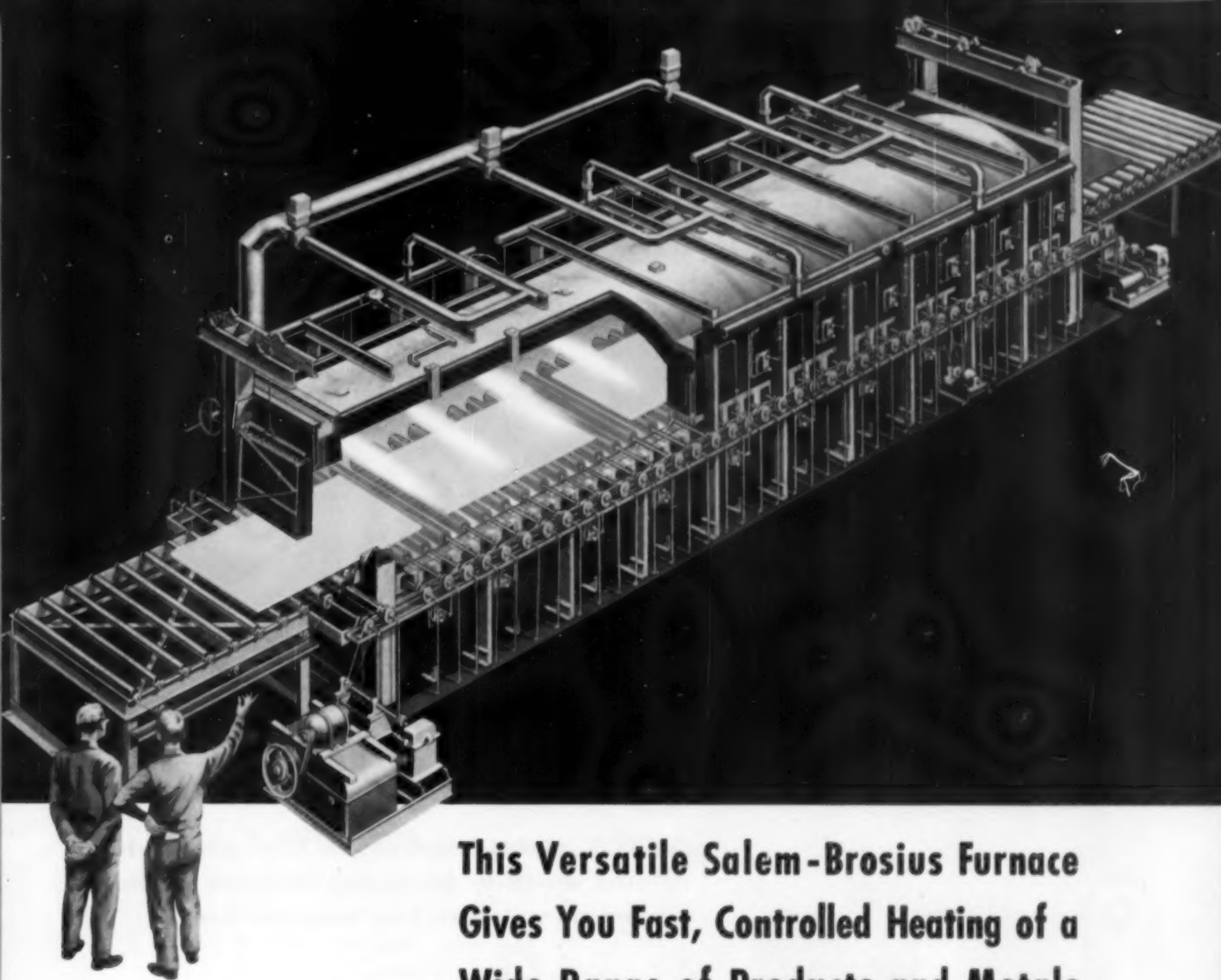
A. B. Lawrason, past-chairman of the Ontario Chapter, is now vice-president and managing director of Bickle-Seagrave, Ltd., Woodstock, Ont., Canada.

D. F. Greenawalt is now employed as metallurgist at the Thor Power Tool Co., Aurora, Ill., after several years with the Rich Mfg. Corp., Battle Creek, Mich., where he served as metallurgist.

John M. Faulkner, formerly production supervisor at Fisher Body Div. of General Motors Corp., Willow Springs, Ill., is now welding engineer with Solar Aircraft Co., Des Moines, Iowa.

Percy C. Still was recently transferred to Dallas, Tex., as district service engineer for the Tennessee Coal and Iron Div. of United States Steel Corp. Mr. Still was formerly service engineer working out of Fairfield, Ala.

Grady Glenn Pendley, formerly employed as an engineer with Cameron Iron Works, Houston, Tex., is now a sales engineer with the Van der Horst Corp. of America, Terrell, Texas.



Br-r-r-r-r

. . . AMPCO* Metal improves its high physicals, retains ductility (does not become brittle) — even at extreme low temperatures

Its ability to perform dependably under conditions of extreme cold without becoming brittle is one of Ampco Metal's more unique properties—but one, nonetheless, that really pays off for designers of Arctic equipment, above-the-atmosphere missiles, gas liquefying machinery, and similar applications. Tests made with Ampco Metal to temperatures as low as –400° F. show that it remains ductile, retains its high mechanical values, even at this brutal, machine-punishing cold.

But the Ampco story doesn't stop there. This series of remarkable alloys gives you high strength-to-weight ratios — tensiles to 110,000 psi with 10 to 15 percent less weight than ordinary bronzes. It combats all forms of wear — sliding wear, erosion, corrosion, fatigue.

All the advantages of one of the world's most versatile metals are yours when you specify Ampco Metal. Get full information from your nearby Ampco field engineer or write us.

AMPCO

Sole Producer of Genuine Ampco Metal

AMPCO METAL, INC.

Dept. MP-6, MILWAUKEE 46, WISCONSIN • West Coast Plant: BURBANK, CALIFORNIA

*Reg. U. S. Pat. Off.

W-136

Personals . . .

William J. Murray ⊕ has been transferred from the Syracuse, N. Y., office of Surface Combustion Corp. to take charge of the Ardmore (Philadelphia), Pa., office, and **William M. Dempster** ⊕ has been moved from the Chicago office to manage the Syracuse office. A graduate of the University of Utah, Mr. Murray has been with the company since 1937. Mr. Dempster has been with Surface since he was graduated from Purdue in 1941, and has been a member of the Chicago sales office since 1946.

Harold O. Warnock ⊕ has been appointed chief plant engineer, and **Jack H. Powers** ⊕ is now superintendent, X-ray and metallography, for Firth-Loach Metals, Inc., McKeesport, Pa. Prior to joining Firth-Loach, Mr. Warnock was mechanical development engineer with Kennametal, Inc., Latrobe, Pa., from 1945 to 1948. He joined the carbide department of Firth-Sterling, Inc., McKeesport, Pa., as tool engineer in 1948, later becoming chief engineer of research department in charge of testing. Mr. Powers started his career in the carbide department of Firth-Sterling, Inc., in 1935, and was assigned to the research department in 1944. He became superintendent of X-ray diffraction and metallographic laboratories in 1952. In conjunction with the Eastman Kodak Co., he has developed techniques for color photomicrography for studying the structure-property relationships of carbide mixtures.

George H. Wurster ⊕ has been appointed manager of forging and die steel sales of Heppenstall Co., Pittsburgh. Mr. Wurster joined the company in 1937 and was made production manager at the Eddystone plant in 1941 and district sales representative in Boston in 1944. Since 1952 he has served as eastern sales manager, with headquarters at Hartford, Conn. He is a graduate of Drexel Institute of Technology, 1937.

C. W. Lueders, Jr. ⊕, with offices in Riverton, N. J., was recently appointed sales agent for the eastern Pennsylvania, southern New Jersey and Maryland territory of the Detroit Electric Furnace Division of Kuhlman Electric Co., Bay City, Mich.

Personals . . .

George Shombert, Jr., assistant superintendent of the electrical test department of Allis-Chalmers Mfg. Co., Milwaukee, Wis., since 1949, has been appointed assistant to the works manager at the company's Pittsburgh works. Mr. Shombert, an electrical engineering graduate of Carnegie Institute of Technology, started with Allis-Chalmers in 1937 as a test department helper.

Warren P. Chernock is now a senior metallurgical engineer in the physical measurements section, engineering development department, atomic energy division, Sylvania Electric Products, Inc., Bayside, N. Y. He was formerly associated with the general research organization of the Olin Mathieson Chemical Corp., New Haven, Conn.

Dale Bittinger is now employed as conversion plate supervisor by Jessop Steel Co. at Colorado Fuel and Iron, Claymont, Del., and Lukens Steel Co., Coatesville, Pa. He was formerly sheet mill foreman for Atlas Steels, Ltd., Welland, Ont.

Robert M. Snyder has been appointed sales engineer for Surface Combustion Corp. in its Chicago industrial sales office. An engineering graduate of Michigan State College, Mr. Snyder has been associated with Surface Combustion since 1948, and has worked in development, estimating, and erection departments on all types of steel mill equipment.

Joseph M. Denny, after completing the work for the doctorate degree at California Institute of Technology, is now a research associate in the laboratories of General Electric Co., Schenectady, N. Y.

Glen W. Wensch recently joined the Division of Reactor Development of the Atomic Energy Commission in the newly created Civilian Power Reactors Branch. Previous to his new position, Dr. Wensch was senior metallurgical engineer for the Vitro Corp. of America, Detroit, and consultant to the Dow-Detroit Edison Study Group on reactor fuels and fuels reprocessing systems.

John W. Carter recently joined United Wire & Supply Co., Providence, R. I., as project engineer.

Personals . . .

Edward H. Robie, assistant secretary of the American Institute of Mining and Metallurgical Engineers for over 20 years and secretary since 1949, has retired and been named secretary emeritus by the Institute's board of directors. **Ernest O. Kirkendall** is the new secretary. He has been secretary of various metals divisions of the Institute for nine years, and is well known to many ASMembers who have attended our Metal Congresses and Expositions, where "Kirk" has directed the meetings of the A.I.M.E. Metals Branches held jointly with the A.S.M.

Robert Draznik, formerly metallurgical engineer at General Electric Co., Fort Wayne, Ind., is now laboratory metallurgist, American Steel & Wire Co., Joliet, Ill.

R. B. Rich, for the past five years in the employ of Revere Copper and Brass, Inc., Baltimore, Md., has been inducted into the U. S. Army.

John P. Denny, formerly research assistant at California Institute of Technology, was recently appointed manager, metallurgy and welding section, general engineering laboratory, General Electric Co., Schenectady, N. Y.

Fred W. De Money is employed as research engineer, mechanical evaluation section, department of metallurgical research, Kaiser Aluminum & Chemical Corp., Spokane, Wash.

Robert L. Ray, formerly employed in the alloy and stainless steel division, Joseph T. Ryerson & Son, Emeryville, Calif., is now a metallurgical engineer, Pyromet Co., San Francisco, Calif.

Ronald A. Kelsey, formerly a research engineer with Aluminum Research Laboratories of Aluminum Co. of America, New Kensington, Pa., is now employed as an engineer in the preliminary hull design section, Electric Boat Div., General Dynamics Corp., Groton, Conn.

M. Scott Brooks, a graduate of Virginia Polytechnic Institute in 1954, is now with the metallurgy division of the National Bureau of Standards, Washington, D. C.

Engineering Design Opportunities in Castings*

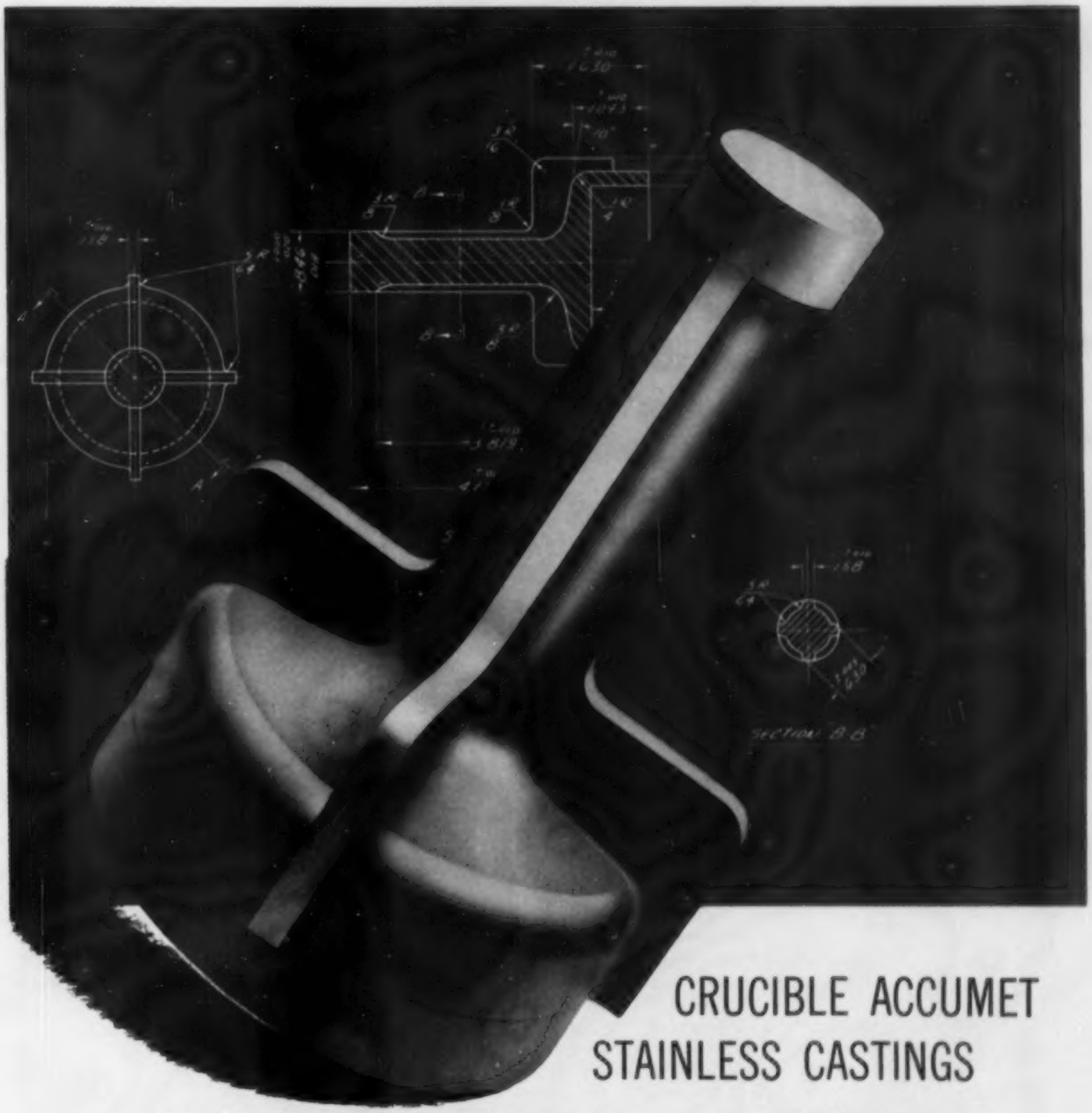
Castings can often successfully replace other methods of fabrication strictly on the basis of merit; however, many of their good properties are not always understood by designers. Casting is the only manufacturing process that has practically no limitation on size (up to 200 tons), shape and intricacy. Some examples of intricacy and detail in castings are automotive motor blocks, hydraulic transmission components and molds for tires. Parts can often be cast to close tolerances with a surface finish that requires no machining or, if extremely fine finish is required, only finish clean-up cuts need to be taken.

Wide choice of casting accuracy and finish is available among the processes of green sand molding, dry sand molding, shell molding, pressure molding, permanent mold and die casting, centrifugal casting, precision casting, plaster molding, graphite molds, and a few others. Tolerances of ± 0.001 in. to ± ¼ in. on a dimension can be obtained, depending on the selection of the casting process and casting design. Surface finishes range in smoothness from 1000 to 20 micro-inches in the various processes. In some processes such as permanent mold, die casting, and graphite mold casting, machined mold surfaces are being directly duplicated in the casting process. The very hard and tough alloys that are difficult to machine can be cast close enough to size and shape so that only grinding is required to bring the parts within tolerance.

The mechanical properties of cast and wrought material having the same composition and heat treatment are usually quite similar. The higher properties normally reported for wrought alloys generally represent tests taken in the direction of working and most often will be higher than for the castings; properties of wrought parts tested in the trans-

(*Continued on page* 150)

*Digest of A.S.M. Lecture Course, "Why Castings", by Hans J. Heine, Technical Director, American Foundrymen's Society, presented before the Louisville, Ky., Chapter in March 1955.



CRUCIBLE ACCUMET STAINLESS CASTINGS

provide smoother surfaces . . . closer tolerances — cut finishing costs

Even intricately shaped parts, like this cream separator neck piece, can be used essentially as-cast when produced by the ACCUMET method. That's because ACCUMET casting employs hot molds with special inner linings. You get castings on which thin sections are minutely defined . . . and with exceptionally fine surface finish. *Costly finishing operations are practically eliminated.*

On this stainless steel part, for example, the only finishing operations necessary are drilling and tapping of the stem section, grinding flats on the bow end, and polishing.

To minimize finishing operations on your products, consider the advantages of ACCUMET precision investment castings. Let your Crucible representative show you how their close tolerances, fine finish, and physical and metallurgical accuracy can spell substantial savings for you. And — to see what information is available on these and other Crucible special steels, write for your free copy of the "Crucible Publication Catalog." *Crucible Steel Company of America, Henry W. Oliver Building, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

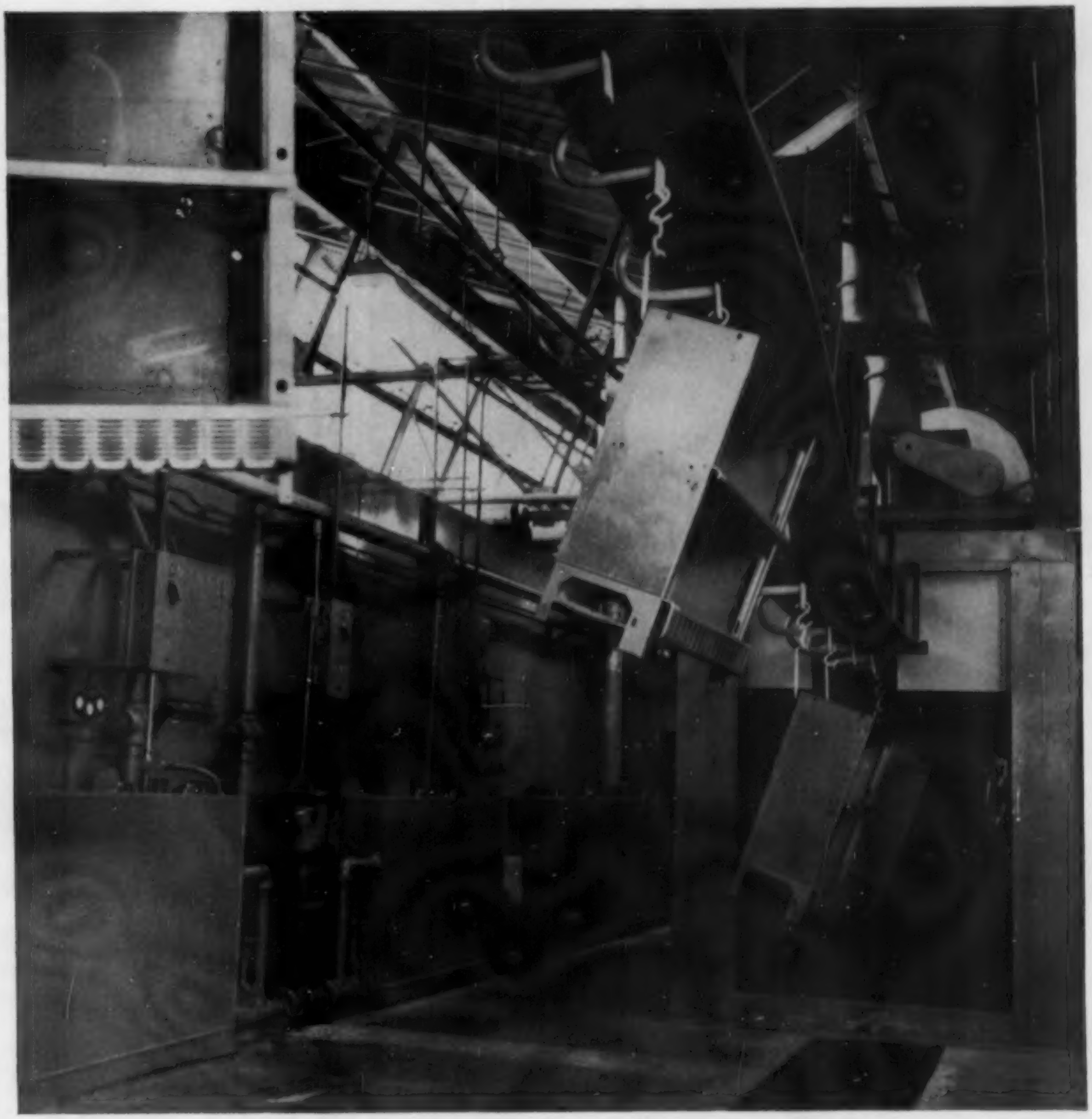
Casting Design . . .

verse direction will be lower than those of castings. This nondirectionality of the properties can be used to advantage in certain designs. Under favorable conditions, metal grains in castings crystallize with a minimum of restraint and are relatively free from residual stress so that the castings are dimensionally stable during machining or heating. Directionality of fiber structure is both an advantage and disadvantage of wrought alloys. If service loads can be directed favorably to the fiber, then the higher property values can be used. However, when loads are perpendicular to the fiber direction, then the lower properties are the limiting ones.

Casting alloys do not exhibit fibering or directionality of properties, except under unfavorable conditions of solidification. The nondirectional properties of castings are associated with the random distribution of metal crystals, dendrites, developed during freezing. Directionality of dendrites and the effect of fibering on properties can be obtained in an improperly designed casting. This condition can be prevented by good casting design.

The freezing rate or section size of the casting has an important bearing on grain size. Large castings and ingots freeze with coarse grains. Thin-section castings, or castings made in metal molds, have small grain on account of rapid freezing. Mechanical working of ingots assists in breaking up coarse grains and promoting a fine grain size. The grain refining action of mechanical working is considered beneficial because higher values of ductility and impact strength are obtained at a given tensile strength having a fine grain. However, many castings have grain sizes not greatly different from those of wrought alloys. Iron-base alloys in sections under 1 in. thick have the desirably small grain size necessary to develop good properties after heat treatment. Most nonferrous alloys retain the grain size developed during freezing of the casting. For this reason, chill castings, those alloys cast in metal or graphite molds, usually display better properties than the same alloys cast in sand. Thus, to make a true appraisal of

(*Continued on page* 152)



Casting Design . . .

property differences which might be caused by grain size differences in wrought and cast alloys, the effects of section size, casting process, heat treatment, chemical composition, and sensitivity of the particular alloy to grain size must be considered.

Alloy groups being used as castings include gray irons (plain and alloyed), malleable and pearlitic malleable irons, steels (carbon, alloy, heat and corrosion resistant), nodular irons, and among the nonferrous alloys those of aluminum, magnesium, copper, nickel, lead, tin, titanium and zinc.

J. P.

Workability of Chromium Alloys*

The workability and ductility of pure chomium and chromium alloys containing 1 to 10% tungsten or 1 to 5% titanium were investigated. Ingots 2 in. long and ⅝ in. diameter were prepared for these tests from electrolytic chromium containing 0.06% oxygen, 0.005% nitrogen, and no metallic impurities that could be detected spectrographically. The metal was arc melted in a water-cooled copper crucible under a purified argon atmosphere. Ingots prepared in this manner had large columnar grains with the longitudinal axis of the grains at right angles to the axis of the ingots. Electropolished, longitudinal specimens taken from the pure chromium ingots were ductile when tested by bending, but transverse specimens were sometimes brittle.

Alloying additions of either tungsten or titanium did not effect any grain refinement in the resulting ingots. As-cast specimens containing up to 5% tungsten or up to 1% titanium were ductile, provided they were electropolished. The 10% tungsten alloy and the 5% titanium alloy were brittle in the as-cast condition.

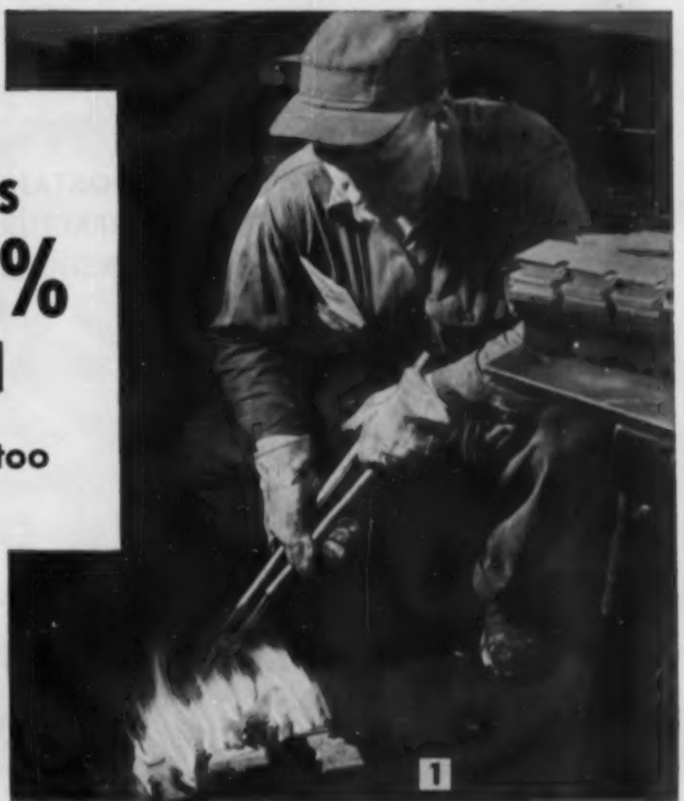
When forged in air, all ingots fractured before there was any ap-

(*Continued on page* 154)

*Digest of "The Fabrication of Chromium and Some Chromium-Base Alloys", by F. Henderson, S. T. Quass and H. L. Wain, *Journal of the Institute of Metals*, Vol. 83, 1954-1955, p. 126-132.

Syracuse cuts tray costs 96% with Inconel

...cuts tool spoilage, too



Breaks trays right and left . . . Nearly every working day, Syracuse Heat Treating Corporation had another silicon carbide tray (costing $3.25 each) broken while heat treating high speed tools. Often they lost four or five tools, as well. In one 5-month period the company replaced 90 broken trays.

Tries Inconel® . . . Because of Inconel's excellent record of withstanding heat and corrosion . . . because Inconel stays strong and tough when hot . . . because it doesn't break when dropped. Syracuse decided to spend $10.00 and try several Inconel trays.

"The cost reduction through the use of Inconel . . . might appear to be fantastic," says Mr. Fred Hunter, General Manager of Syracuse Heat Treating Corporation, but it "is a matter of record."

It's a matter of record in many firms that Inconel saves money in high temperature equipment. And, it's easy to handle . . . readily shaped, welded, and machined.

Stops Thermal Shock Breakage . . . The company got immediate relief from breakage. Neither mechanical shock nor the thermal shock of clamping trays at 2300° F. with cold tongs fazed Inconel. Syracuse had no trouble with distortion either.

So look into the hot spots in your plant. Maybe Inconel will save you money, too. To get more information, write for free booklet, "Keep Operating Costs Down . . . when temperatures go up."

Cuts costs $282.50 . . . plus . . . In the first five months of using Inconel, Syracuse saved $282.50 (96%) in tray costs alone. Tool spoilage went down, too. The company considers that quite a return on its $10.00 investment for Inconel . . . points out (see picture above) that trays have lots more life left.

Inconel

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.

INCO NICKEL ALLOYS

for long life at high temperatures

Chromium Alloys . . .

preciable reduction in area. To prevent cracking, the ingots were sheathed in steel jackets, upset forged, and then draw forged. Sheathed ingots of pure chromium and of the 1% tungsten alloy could be forged at 1650° F. For the 1% titanium alloy and the 5% tungsten alloy, the forging temperature had to be increased to 2190° F. The sheath of mild steel was too plastic at this temperature and had to be replaced with an alloyed ferritic steel. The 5% titanium alloy and the 10% tungsten alloy could not be forged even at 2460° F. A borax salt bath at 2190° F. was satisfactory for heating and working unsheathed ingots of lower alloy content. Presumably, a lower bath temperature could be used with larger ingots because the small ingots lost temperature rapidly when they were removed from the bath.

The forging treatment refined the as-cast grain structure of the ingots but did not break up the oxide network around the grain boundaries. After removal of the surface by electropolishing, the forged specimens were ductile.

Forged billets of pure chromium and 1% tungsten alloy were swaged with further refinement of the grain size. To prevent cracking, the forged billets had to be ground and polished before they were resheathed in steel. A swaging temperature of 1650° F. and a reduction in area of 15% between passes were satisfactory. Electropolished swaged rod was ductile at room temperature and some specimens could be bent rapidly to 90° or twisted through 360°.

It was impossible to produce swaged rod directly from arc melted ingots because of severe cracking that occurred during the swaging operation. No attempt was made to swage the alloys containing 5 and 10% tungsten or 1 and 5% titanium.

Rolled strip was produced from both swaged rods and forged bars. As in the other working operations, it was necessary to sheath the chromium before it was rolled. For rolling, however, it was necessary to use a composite sheath of mild steel and stainless steel. The reason for the composite sheathing was that mild steel flowed much more easily than the chromium, and stainless steel

(*Continued on page 156*)

UDDEHOLM STOCKS THE TOOLMAKER'S STANDBY

SAE/JIC-01 (Carbon .90%, Manganese 1.20%, Silicon .25%, Chromium .50%, Tungsten .50%, Vanadium .20%) is a time-tested, oil-hardening, non-deforming analysis for general tool and die work. Uddeholm calls it UHB-46. It is available from stock in all the forms illustrated:

1. UHB-46 drill rods
2. UHB-46 flat ground stock
3. UHB-46 hot-rolled bars
4. UHB-46 special sections
5. UHB-46 hollow bars

And, we will deliver UHB-46 in special forgings.

With such a wide variety of sizes, shapes, and finishes, you can make all heat-treated components of a tool or die from one analysis and get them all from one source—Uddeholm. From that same source you get Uddeholm Swedish quality and Uddeholm service.

Furthermore, you can get many other grades of tool and die steels. The most generally used types, in an extremely wide range of sizes and shapes, are always on hand. Stocks are carried in New York, Cleveland, and Los Angeles.

WANT A STOCK LIST OF UDDEHOLM TOOL STEELS?

UDDEHOLM, 155 East 44th St., New York 17, N.Y.

Please send me______tool steel stock lists.

NAME______________________________

TITLE______________________________

COMPANY____________________________

ADDRESS____________________________

CITY________________ZONE______STATE______

UHB

UDDEHOLM COMPANY OF AMERICA, INC.

Tool and Die Steels
Specialty Strip Steels

New York: 155 East 44th Street, MUrray Hill 7-4575
Cleveland: 3756 Carnegie Avenue, HEnderson 1-7440
Los Angeles: 5037 Telegraph Road, ANgelus 2-5121

Chromium Alloys . . .

bonded to the chromium and was impossible to separate from the finished strip. By placing mild steel between the chromium and the stainless steel, the sheath could be removed easily after rolling.

Pure chromium was rolled in the temperature range of 840 to 1650° F. After rolling, the strip was fine grained with the grains elongated in the direction of rolling. As the rolling temperature was decreased, the amount of grain elongation was increased. Annealing of the strip at 1650 to 1742° F. produced equiaxed grains.

In general, pure chromium strip was brittle after being removed from the sheath but was ductile if the outer layers were removed by pickling in a 50% solution of hydrochloric acid. To reduce embrittlement during rolling, the chromium was either plated with iron or copper before sheathing or sheathed under an atmosphere of argon. Iron plating was somewhat more effective than the other methods. Removal of 0.002 to 0.003 in. of metal from each surface was sufficient to restore ductility.

To determine the tensile properties of pure chromium strip, specimens $2.5 \times 0.175 \times 0.025$ in. were machined from rolled strip and tested at room temperature. The tensile properties of the more ductile specimens were as follows:

Proof strength, 0.2%	55,000 psi.
Ultimate strength	74,000 psi.
Elongation	15%

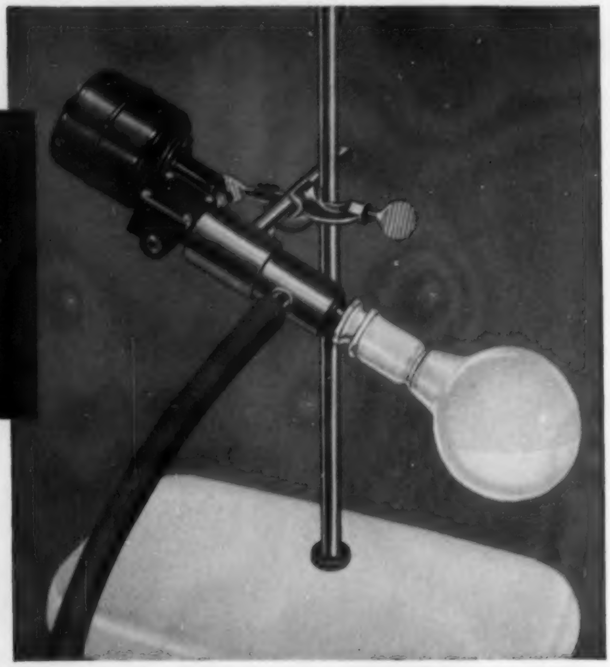
The techniques used for rolling pure chromium were successful for rolling 1% tungsten alloy at 1650° F. The 5% tungsten alloy and the 1% titanium alloy could not be rolled at 1650° F. but could be rolled at 2190° F. At this temperature, however, a nickel-chromjum-molybdenum ferritic steel had to be used for sheathing in place of mild steel. The 10% tungsten alloy and the 5% titanium alloy could not be rolled. As-cast chromium and chromium alloys also could not be rolled successfully.

This report reveals that pure chromium and chromium alloys can be hot worked if the material is initially of a high degree of purity and if impurity pickup during fabrication is reduced to a minimum.

R. M. Lang


40 YEARS
of quality metals . . .
1955 marks 40 years of quality alloys by Titan metal specialists. Brass and bronze free-cutting rods, extruded brass shapes, bronze welding rods, brass wire, aluminum and brass hand screw-machine parts, brass pressure die castings, brass, bronze and aluminum forgings are produced to meet high standards and rigid requirements. Titan Metal Manufacturing Co., Bellefonte, Pa. Offices and agencies in principal cities.

for rapid evaporation of solvents of low volatility



use

THE RINCO ROTATING VACUUM-TYPE EVAPORATOR

(Patent Applied For)

● For speeding up routine evaporations. Handles volumes from 1 c.c. to 1000 c.c. Principle utilized — rotation of flask spreads out thin film over large area (diameter of flask) subjected to negative pressure. "Bumping" eliminated. Use of glass beads unnecessary. Rate of evaporation increased 4 to 5 times, depending on solvent used. Particularly advantageous with such solvents as water, dimethylformamide, etc. 30 ml. of water at 20° C will be evaporated in 30 minutes or less. Very useful with heat sensitive compounds and biological extracts since no temperature increases are necessary. Evaporator will, of course, operate satisfactorily at higher evaporation rates with increased temperature, when sample characteristics permit application of heat.

Evaporator consists essentially of a stainless steel shaft with a machined Standard Taper 19/38 joint at lower end. Shaft rotates on oilite bronze bearings within stainless steel housing having Standard Taper 12/30 take-off leading to vacuum pump or aspirator. Vacuum pump and trap are recommended for best results, but can be used with aspirator. Flask attached to Standard Taper joint at lower end of shaft rotates at approximately 60 r.p.m. by means of special motor. Standard Taper 19/38 joint accommodates smaller capacity flasks, i.e., 50 ml. H-63620 Reducing Adapters, Pyrex Brand Glass, permit use of larger flasks having Standard Taper 24/40, 29/42, etc. Entire apparatus can be easily disassembled for cleaning.

Can be adapted to single or multiple units.

H-21655 — Rinco Rotating Vacuum-type evaporator complete with motor and cord for use on 115V 60C, A.C. . . . **$96.50**

Note: Support stand, clamp and glassware are accessories and may be ordered separately.

HARSHAW SCIENTIFIC
DIVISION OF THE HARSHAW CHEMICAL CO.
CLEVELAND 6, OHIO

Cleveland 6, Ohio 1945 East 97th St.
Cincinnati 13, Ohio 6265 Wiehe Road
Detroit 28, Mich. 9240 Hubbell Ave.

HARSHAW

Houston 11, Texas 6622 Supply Row
Los Angeles 22, Calif. 3237 S. Garfield Ave.
Philadelphia 48, Pa. Jackson & Swanson Sts.

Tool Steel Topics

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

They Wing Screw Drivers at Fast Clip with Dies of BTR

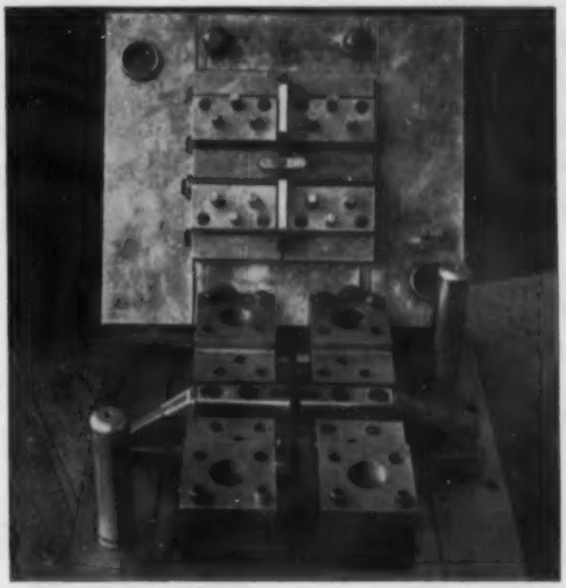
It's efficiency-plus at the busy plant of Oxwall Tool Co., Ltd., Oxford, N. J. For here there's every kind of machine for the high-speed manufacture of all kinds of quality screw drivers. They turn them out by the millions, large and small, including an ingenious worm-like screw driver which can be bent around corners at the touch of a finger.

The plant has a battery of 10-ton presses where the wire blank is winged on the end opposite the blade (see illustration above) so that it can be anchored in the plastic handle. The typical forming dies used in this operation are made of BTR (Bethlehem Tool Room) tool steel. Oxwall engineers tell us that these BTR dies, hardened to Rockwell C48-50, are giving long service life in this application.

BTR is our general-purpose, manganese-chromium-tungsten grade of oil-hardening tool steel, perhaps best known for its safe hardening property. It also has good abrasion-resistance and toughness, and is ideal for practically every application where long wear is desirable.

If you would like to give BTR a workout in your shop just put in a phone call to your Bethlehem tool steel distributor. You'll find him well stocked with BTR, and anxious to be of service to you.

Assortment of screw drivers made by Oxwall Tool Co., Ltd. Each blank is winged by a die of BTR tool steel, for firm anchorage in handle. Model shown in illustration at the upper right, with flexible shaft which can be bent as needed, is an ideal time-saver for cramped quarters.



SHOCK-RESISTANCE PAYS OFF AS DIE MADE OF 67 CHISEL PUNCHES HOLES IN HIGHWAY GUARD RAIL

Because of its excellent shock-resisting properties, this die of Bethlehem 67 Chisel tool steel provides economical punching of bolt holes in beam-type highway guard rail. The die, hardened to Rockwell C-51, operates in a 200-ton press. In addition to its shock-resistance, 67 Chisel is wear-resistant, making it ideal for such applications as shear blades, hot-work tools, blanking tools and swaging dies.

BETHLEHEM TOOL STEEL ENGINEER SAYS:

Here's How to Harden Tools with Holes

Ordinarily holes in tools cannot be eliminated. Nor can their size or location be changed, in most instances. So steps must be taken to control the ill effects of holes, such as tools cracking during the hardening operation. Although it is impossible to outline a procedure for all tools, the following principles are recommended for those containing holes:

1. Quench tools so that the internal surfaces of the tools harden completely. When holes are relatively large, no special attention may be necessary; for small holes, flush-quenching may be required.

2. If it is possible that effective quenching may not occur completely throughout the holes, pack them so that hardening cannot take place in the holes, assuming that this condition is allowed on the tool. Use clay, asbestos, steel wool or steel inserts.

3. If only the surface of a hole is to be hard, as on a ring die, flush-quench the bore while protecting the outside surface from the quench.

The internal surface of a hole should be either uniformly hard, or uniformly soft. The worst possible condition is an irregular hardness pattern on the inside surface, because the high stress developed may result in cracking.

Anodizing and Painting of Aluminum Alloys*

Although aluminum-magnesium silicide alloys of the H 10 type are now widely used in Great Britain for engineering purposes and in transportation, experimental data on the corrosion fatigue properties of this alloy are scanty. A series of fatigue and corrosion fatigue tests was made on a selected H 10 alloy (0.07 Cu, 0.20 Fe, 0.58 Mn, 0.61 Mg, 0.94% Si, trace Ti) in the unprotected, anodized and painted conditions in the following media: air, distilled water, 3% sodium chloride, Birmingham tap water (about 50 parts per million total dissolved solids) and metropolitan London tap water (360 ppm. total dissolved solids).

Endurance of H 10 Alloy at 10^8 Cycles
(in Long Tons per Sq. In.)

Surface Condition	Air	London Tap Water	3% Salt Solution
Unprotected*	8.0	4.0	2.1
Anodized, water seal	7.0	7.0	6.0
Anodized, dichromate seal	7.0	6.0	6.6
Painted	9.0	—	8.8

*Endurance in distilled water 5.9 tons per sq. in.; in Birmingham tap water 4.2 tons per sq. in.

A direct chill cast billet of the alloy was heated to 930° F. and extruded to ⅝-in. diameter rods from which the test pieces were prepared. Prior to final machining, all test material was solution heat treated in a salt bath at 975° F. for ½ hr., artificially aged at 320° F. for 18 hr. and air cooled. Results of tensile tests on specimens prepared in this way conformed to the usual specifications for this type of material.

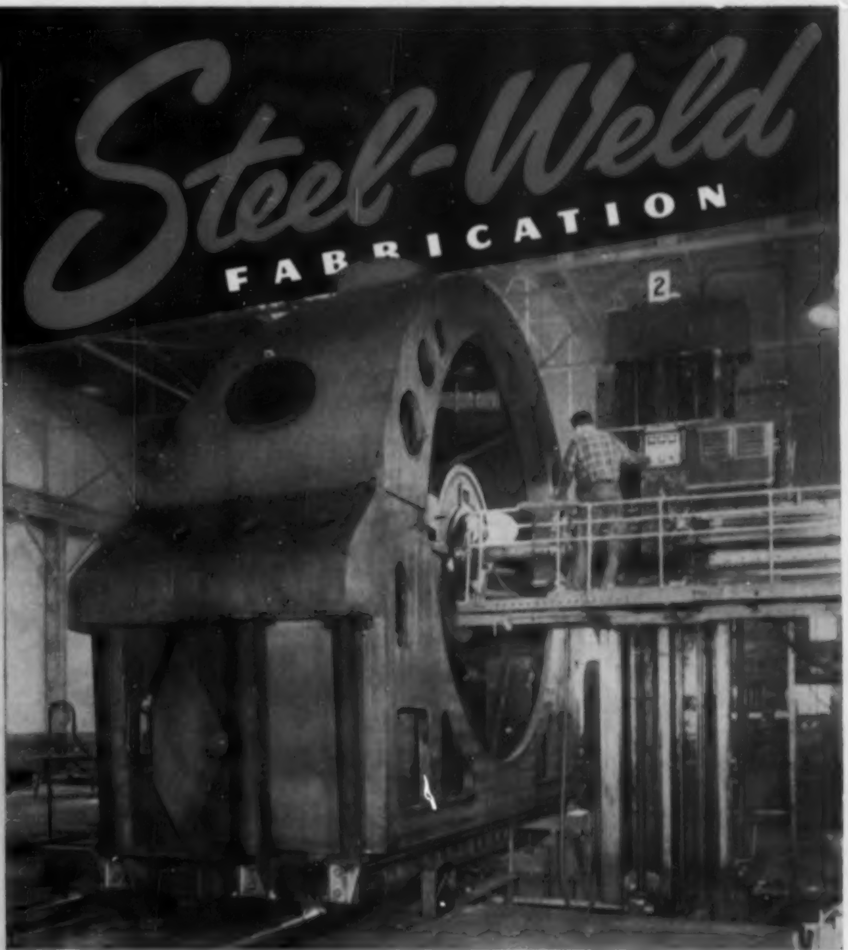
Carefully machined and polished fatigue test specimens were anodized for 30 min. at 68° F. in 20% sulphuric acid. The two sealing procedures employed for the anodized specimens were 30 min. in boiling water for one group and 30 min. in boiling 5% potassium dichromate solution for the other. (Reviewer's Note: No statement is made as to the pH and purity of the sealing water. Both factors are known to be of importance in evaluating the corrosive behavior of anodized and sealed aluminum alloys.)

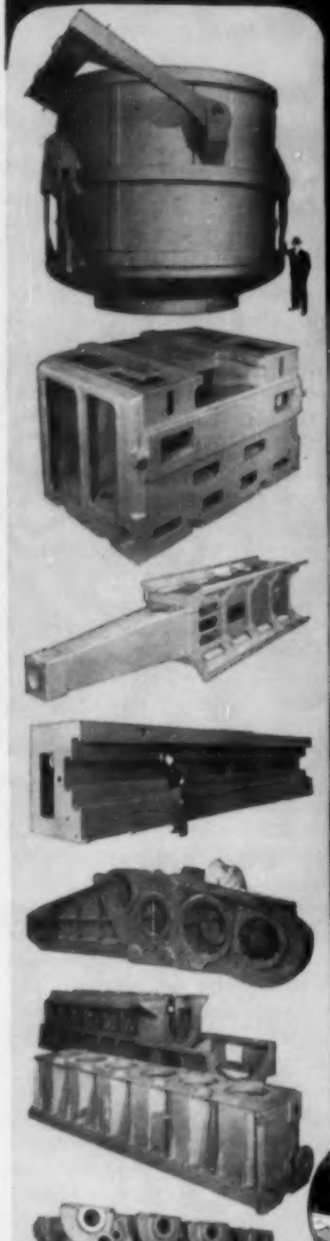
Additional machined and polished fatigue specimens were painted according to the following procedure:

1. Vapor degreased in trichlorethylene.
2. Given a proprietary chemical conversion coating of the chromate type.
3. Cold water rinsed and then given a warm acidulated water rinse.
4. Dried and then coated with a red oxide-chromate primer, followed by a 24-hr. air dry.
5. Spray coated with a proprietary alkyd finish automotive paint.

(Continued on p. 160)

*Digest of "Corrosion-Fatigue Properties of an Aluminium-Magnesium-Silicon Alloy in the Unprotected, Anodized and Painted Conditions", by N. P. Inglis and E. C. Larke, *Journal* of the Institute of Metals, Vol. 83, December 1954, p. 117-120.





Use WELDED STEEL for Greater Strength with Less Weight!

Precision machining operations on heavy cumbersome pieces, such as the base and cover of a 200,000 kw Steam Turbine illustrated above, are not uncommon in the Steel-Weld Division of the Mahon Company. Mahon service to manufacturers of processing machinery, machine tools, and other types of heavy mechanical equipment is complete in every respect: Design-engineering, Fabrication, Magnetic and Radiographic Inspection, Stress Relieving, Grit Blasting, Machining and Assembling. If you use weldments in your product, or if parts of your product could be produced to better advantage in welded steel, you will find in the Mahon organization a unique source . . . a source where design skill and advanced fabricating technique are supplemented by craftsmanship which assures a smoother finer appearing job embodying every advantage of Steel-Weld Fabrication. See Sweet's Product Design File for information, or write for Booklet showing Mahon facilities and capabilities in this field.

THE R. C. MAHON COMPANY
DETROIT 34, MICHIGAN

Engineers and Fabricators of Steel in Any Form for Any Purpose

MAHON

Anodizing . . .

(The curing schedule is not reported.)

Fatigue testing was done in a rotating (5000 rpm.) cantilever-type machine with the load arranged to produce a uniform bending moment over the reduced parallel portion of the specimen. For tests under corrosive conditions, the corrosive medium was dropped continuously on the reduced parallel portion of the specimen at a rate of approximately one drop per second.

S-N curves are given for all surface conditions tested in air and in the four corrosive media. Significant losses in endurance strength occur in corrosive media in a relatively small number of cycles; for example, 10^6. All curves continue to fall quite steeply even after 10^8 cycles and therefore it was impossible to obtain a value for endurance strength independent of the number of stress reversals. Accordingly, comparison between different surface conditions and corrosive media is based on the endurance strength values at 10^8 cycles. The tabulation at top of p. 158 gives the approximate endurance strength in long tons (2240 lb.) per square inch at 10^8 cycles for the various surface conditions and test media.

There is a serious drop in endurance strength of unprotected material when exposed to any of the corrosive media. The slightly better performance in air of the painted specimens, as compared with the unprotected specimens, is taken as an indication of slightly corroding influences under atmospheric conditions. The value of anodizing as a protection against corrosion fatigue is evident, with both methods of sealing having approximately equal value.

The finding that anodizing causes a loss of fatigue strength in air agrees with several previous investigations. Microscopic examination revealed small surface defects in the anodic coatings, which were presumed to act as stress-raisers under the test conditions.

Detailed microscopic examination was performed on at least one failed specimen from each of the 13 test conditions. In general, fracture took place at right angles to the axis of the specimen. All fractures, irrespective of corrosive medium, were predominantly transcrystalline in character. This was somewhat in contrast with the intercrystalline character of the ordinary corrosion which takes place in H 10 alloys. These results are interpreted as supporting the view that the role of a corrosive agent in corrosion fatigue is to form a pit which acts as a stress-raiser with the resulting increase in stress causing a continuous mutual intensification of pit deepening and stress increase.

The conclusions are:

1. The fatigue strength of a heat treated H 10 alloy is greatly reduced by mild corrosive agents such as distilled water and normal tap waters.

2. The reduction in fatigue strength in a severe corrosive agent, such as 3% salt, is even more pronounced.

3. Anodizing affords considerable protection against corrosion fa-

(Continued on p. 162)

Anodizing . . .

tigue. However the fatigue strength in air of anodized material is somewhat less than that of unprotected material.

4. Careful painting gives extremely effective protection against even the most severe corrosion fatigue conditions.

5. All fatigue cracks are predominantly transcrystalline, and the type of cracking and general mode of failure are not affected by the corroding medium.

REVIEWER'S NOTE: The spread in replicate data in this kind of work is frequently as much as 10%. The authors did not indicate the number of samples taken for each point given in the S-N curves. Only for the curves drawn for the unprotected condition is there a clear demonstration of the differences in results for each environment. For the other surface conditions, the differences for the various environments are no greater than might be expected from normal statistical scatter. This is not meant to question the authors' general conclusions, which appear quite valid.

G. H. KISSIN

Taphole Clays*

THE TYPES of materials used as taphope filling and the properties of 12 commercial clays mixed with varying amounts of coal, silica, and grog were studied in this investigation. Following the laboratory studies, mixtures were tried in the iron tapholes of three operating blast furnaces to assess their value.

The English, apparently, prefer a mixture of about 40 to 50% grog with 50% plastic clay to which varying amounts of high-ash coal (20%) are added. Grog is usually ground, broken firebrick but crushed ganister may be substituted. Chemical analyses of the 12 clay-grog mixtures showed a wide variation in composition. Silica content varied between 39 and 64%; alumina between 3.8 and 28.0%, but was usually about 25%; Fe_2O_3 between 2 and 6%; lime and magnesia under 10% each; loss on ignition between 6 and 24%. These analyses are taken of the clay-grog mixture before the coal addition. All of these mixtures gave satisfactory results in actual operations, indicating that composition is not significant.

Drying and firing shrinkage were determined by measuring the change in length of dried or fired bars whose original dimensions were 4 in. long, ½ in. wide and 1 in. thick. Green-strength tests were made on bars dried at 230° F. The moisture content varied between 12 and 20%; dry shrinkage between 1 and 5%; green strength between 35 and 254 psi. The shrinkage on firing dried test pieces at 2030° F. was very slight, ranging between 1 and 3%. The apparent porosity after firing at 2030° F. varied from 24 to 53%, but most of the samples had a porosity of about 30%. The highest porosity occurred in the mixture with the lowest silica content (39.8%) and highest alumina (28%). The refractoriness of the mixture, called "squatting" tests by the authors, varied between 2550 and 3040° F. The mixture with the lowest "squatting" temperature contained the highest amount of Fe_2O_3 (5.62%) and alkalis (3.8%). The highest "squatting" temperature (3020° F.) was record-

(Continued on page 164)

*Digest of "Investigations of Taphole Clays and Taphole Practice", by W. Banks and H. M. Richardson, *Journal* of the Iron and Steel Institute, Vol. 178, October 1954, p. 138.

Ten Million TOCCO*-Hardened Axle Shafts

Battery of TOCCO machines for hardening automotive axle shafts. TOCCO*-hardened shafts show an increase of up to 200% in resistance to torsional fatigue over furnace-hardened shafts made of alloy steel.

Give Super Service to American Motorists

...Save Manufacturers $2,000,000

The application of TOCCO* Induction Heating to the surface hardening of rear axle drive shafts for passenger cars and trucks provides a fine example of how a less expensive manufacturing method often results in the best possible end product.

For instance, TOCCO* Induction Hardening permits the substitution of easier machining carbon steels for expensive alloys, saving from 25¢ to 55¢ per car in material costs alone. Additional savings result from the fact that TOCCO eliminates the need for annealing, tempering and shot peening operations formerly required. Moreover, long hauls to and from the heat-treating department are eliminated because cool, clean TOCCO* fits right in the production line—next to related operations.

If you make parts that require hardening, annealing, brazing, or heating for forging or forming, it can pay you handsome dividends to investigate TOCCO* Induction Heating as a sound method of improving product quality *while reducing costs.*

THE OHIO CRANKSHAFT COMPANY

JUST PUSH A BUTTON

TOCCO

Mail Coupon Today

NEW FREE BULLETIN

THE OHIO CRANKSHAFT CO.
Dept. R-6, Cleveland 1, Ohio
Please send copy of "Typical Results of TOCCO Induction Hardening and Heat Treating."

Name____________________
Position____________________
Company____________________
Address____________________
City__________ Zone____ State______

Taphole Clays . . .

ed on the mixture with lowest silica (39.8%) and highest alumina (28%); apparently a higher content of mullite would result on firing this sample.

Two series of tests were made to determine the resistance of the clay mixtures to the corrosive action of a typical English blast-furnace slag. The analysis of the slag was 30% SiO_2; 20.7 Al_2O_3, 1.5 MnO, 39.5 CaO, 6.8 MgO, 1.9 S and 0.6% FeO. The first tests on slag action consisted of molding a 3-in. cubic block of the clay mixture, drilling a 1-in. diameter hole 1 in. deep in this block, filling the hole with crushed slag and then firing the assembly at 2190° F. There was practically no attack by the slag on the clay mixture at this temperature. A second test was made by mixing 20% and 40% of the ground slag with each clay mixture and then firing the cones to determine the temperature of initial deformation of the cones. For the 20% slag mixture, the "squatting" temperature varied between 2190 and 2550° F., and for the 40% slag mixture between 2120 and 2440° F. These cones had a softening temperature that was 360 to 540° F. lower than that given previously for the clay mixture containing no slag. The low-silica (40%), high-alumina (28%) clay again showed the highest temperature at which deformation of the cone occurred.

Bar specimens 4 × 1 × ½ in. were molded of each clay with 0, 10, 20, and 30% of fine coal for studies of the effect of these coal additions. Drying shrinkage of each bar was measured and then the bars were fired for 2 hr. at 1110, 1470, 1830 and 2190° F. in an atmosphere of nitrogen. After each firing the loss in weight, shrinkage, and apparent porosity were measured. The volume of each specimen remained nearly constant for firing temperatures up to 1470° F., but above 1650° F. the shrinkage increased for clays with the higher coal additions. Up to 1470° F. shrinkage varied between 0.7 and 1.5%; at 2190° F. between 3.8 and 5.9%; at 2550° F. between 9 and 13%. The porosity increased for each mixture up to a maximum of 1830° F., the higher coal contents causing the greatest increase. At this temperature the mixture with no coal showed 32% porosity which increased to 38% with 30% coal. Above 1830° F. porosity decreased rapidly with increasing temperature as vitrification set in. At 2550° F. all samples showed less than 27% porosity.

Following these extensive studies at the laboratories of the British Ceramic Research Assoc., actual tests of clay-grog-coal mixtures were tried on two blast furnaces. The thickness of the furnace wall was about 4 ft. and to fill a hole of this depth requires 4 to 5 cu. ft. of clay. Using one of the clay mixtures containing either 10 or 20% coal, studies were made of the performance of the clay in the blast furnace. The most interesting results developed from measurements of taphole temperatures by inserting thermocouples to various depths and by drilling core samples for analysis and X-ray studies of the minerals present at various depths.

(Continued on page 166)

Taphole Clays . . .

The temperature gradient in a 4-ft. long taphole showed a maximum temperature of 1110° F. at 3 ft., 6 in. from the furnace shell, 1110 to 1830° F. in the next 3 in., and up to 2730° F. for the remaining 3 in. In the coolest zone drying shrinkage is the important property of the clay mixture, and in the intermediate zone firing shrinkage is most important. The hottest zone consisted of vitrified clay and then a mixture of iron and clay containing silica, iron, cementite, iron phosphide, and mullite.

At the interface a small amount of ferrous silicate was present and iron phosphide had penetrated the porous vitrified clay surface. The samples nearest to the molten iron consisted mostly of quartz, mullite and cristobalite. The original mineral kaolinite was identified in samples only 2 to 3 in. back of the interface, indicating that the temperature here was not high enough for vitrification of the clay mixture. Because no lime was found, it was assumed that slag did not attack the taphole clay.

Conclusions

1. Although the chemical composition of the taphole clay mixture may vary, its drying shrinkage should be low.

2. The use of a powerful taphole gun is essential.

3. The maximum percentage of fireclay in a grog-clay or in a ganister-clay mixture will depend on the plasticity and particle size of the particular clay, and on the strength of the taphole gun. A strong gun may force a mixture of low clay content into the hole but more clay will be needed with a weaker gun.

4. The addition of coal facilitates drying of the mixture between casts and the drilling of the hole because it increases the porosity of a dry or fired clay-grog mixture. (If too much coal is used a weak hole will result.)

5. Although no marked chemical attack between molten metal and the taphole mixtures was observed, slag will react with fireclay and grog. To keep this slag attack at a minimum, it is important to use only a small volume of roughing slag in the mixture. Also, the mixture should contain a refractory grog.

E. C. Wright

Powder Metallurgy for Atomic Engineers*

AFTER giving a simplified account of how a nuclear power reactor can be constructed, the authors note that it involves several major problems due to the facts that the interval temperature of the fuel elements will be as high as 1300° F., that the coolant or heat transport medium (helium, argon, liquid sodium, pressurized water or whatever) must not pick up particles of fuel or corrode the external piping system or the heat exchanger, and that the materials of reactor construction will suffer from intense neutron bombardment. Much study on the latter problem indicates that the metals generally increase in yield strength (and hardness of annealed metal) due to disorganization of the crystalline lattice and even the creation by transmutation of atoms of new alloying metals.

The bulk of the paper discusses in general terms the way structural units made by powder metallurgical methods may be expected to differ from those made by conventional methods when exposed to conditions within a power reactor.

First as to crystal lattices:

Any powder particle has much surface and little mass. The crystal lattices at the surface are highly disordered, having large amounts of lattice vacancies, dislocations or other disturbances. More lattice distortions in the metal powders are produced during compacting, under the very high pressures which exist in the contact areas. During sintering, the lattices rearrange to a certain extent but very seldom end up in ordered structures. Thus the disordered lattices resulting from the powder metallurgical processing are likely to make a susceptible material more resistant to radiation effects.

Grain Structure – Grain growth is a matter of greatest importance. The compact contains a large amount of highly cold worked powder particles. Between the particles are voids – 10 to 30% of the compact volume. Even before, but especially after compact-

*Digest of "The Role of Powder Metallurgy in the Design of Nuclear Power Reactors", by Henry H. Hausner and Milton C. Kells. Paper read before the April 1955 meeting of the American Society of Mechanical Engineers.

Powder Metallurgy . . .

ing, a large number of nuclei for recrystallization are formed, which leads, in a general way, to small grain sizes. The voids also act in a manner similar to impurities in hindering or delaying grain growth during sintering – especially during the earlier stages. In the end, both the cold work and the voids cause powder metallurgy products to possess smaller grains in the structure.

Alloying by powder metallurgy is an especially good way to avoid segregation in alloys between very heavy and very light metals. Furthermore, since sintering temperatures are below melting temperatures, there is far less chance of contamination from containers or from atmospheres. Metals of controlled porosity can also obviously be so made. Finally, useful mixtures of metals and nonmetals (cermets) can only be made from powder mixtures.

Bonding for heat transfer purposes is especially necessary for fuel elements, which must be clad with a protective metal, and this must be well bonded in order to transfer the heat generated internally. Powder metallurgy offers some advantages in this respect. Diffusion of one metal into another requires high temperature or long time; to lower the diffusion temperature or decrease the diffusion time, the metals should have high surface activity, which usually exists in metal powder particles in comparison with cast or forged metallic bodies.

Fabrication of the "new" metals relies much on powder metallurgy. Of these, uranium and thorium are fuel materials; beryllium is an excellent moderator; and zirconium can be used as a noncorrosive cladding material. Beryllium is brittle and can be ground into powder. It must be sintered in a nonoxidizing atmosphere such as argon or vacuum. The argon sinters are brittle; vacuum-sintered metal shows some ductility, inasmuch as it can be cold rolled approximately 10%, annealed, and again cold rolled. This fact can be explained by the evaporation of beryllium, which starts at fairly low temperatures and acts as an additional sintering mechanism, giving grains of favorable size and shape.

Uranium, thorium and zirconium

(Continued on p. 170)

Powder Metallurgy . . .

are not brittle and cannot be ground so easily; however, they form brittle hydrides. Decomposition of these hydride powders occurs in vacuo at elevated temperatures, and the metal powders formed in this way are applicable to any powder metallurgical process. Zirconium indeed has been found to be an almost ideal material for powder metallurgy, inasmuch as it sinters to high density at temperatures far below its melting point. Thorium also densifies at fairly low temperatures.

Handling of these powders is not as easy as ordinary metal powder. Beryllium, in powder form, is highly toxic; zirconium, in fine particle sizes, is highly pyrophoric; and the powders of uranium and thorium are both toxic and pyrophoric. They must be handled with greatest care in special equipment. E. E. T.

Correspondence . . .

(Continued from p. 124)

sponsored by N.P.A. Metal Working Div., both issued March 13, 1952, reflected the results of this close cooperation. Within months the pressure was relieved, and of actually required supplies, only those backlogs of orders existed which are to be found at normal times in every active industry.

This statement on the present situation is made as a result of studies and analyses of reports. Some two or three of the many substitute methods for machining of the hard carbide materials can be used effectively, within limits, in certain partial phases of mechanical production. Improvement in these processes can be expected. But much of the processing that has required industrial diamonds will continue to require industrial diamonds. At best, substitute methods still would be substitutes and costly to use.

The use of the supplementary aid to machining mentioned above together with the Government stockpile, and a supply of industrial diamonds and tools always in the hands of the various branches of the industry, would provide all American industry requirements for a long period. It then only would be necessary in a time of national emergency

(Continued on p. 172)

Remember —YOUR COST PER FINISHED ARTICLE IS THE TRUE COST OF YOUR CLEANER

Northwest's years of research in formulating and perfecting analytically correct, job-adjusted cleaners are your assurance of the right chemical for your job.

Northwest's Metal Cleaning Specialists have at their command such outstanding processes as LO HI pH—for cleaning prior to plating, painting or vitreous enameling; ALKALUME—for preparing aluminum for finishing and spot welding; INTERLOX—for phosphate coating; SPRA-LUBE—to control overspray of "todays" paints in water-wash paint booths; PAINT STRIPPERS—specific to your needs; SUPER-DRAW AND FLUID FILM—for drawing metals.

Northwest's production-tested chemicals and "Right the First Time" recommendations will save you money. Your Northwest Cleaning Specialist is as close as your phone.

Correspondence . . .

to quickly resume the same moderate controls as were established by N. P. A. Order M-102 and M-103 "during Korea". At that time not one wheel in industry failed to turn for lack of industrial diamonds.

In addition to the above, it appears advisable again to add that this Association and its members constantly are working to inform users of industrial diamonds of the methods that prolong the life of diamond tools, and that diamond tool producers will continue to make their products more efficient and more durable. These activities and the reclamation of diamond material from used tools are tantamount to stretching the supply even beyond the safety limits which already will have been pushed back, in times of emergency, by the methods described in the preceding paragraphs.

In view of the frequent repetition of a theme by writers whose error, from a perusal of the above, is easy to understand, this critical industry risks severe damage. It is earnestly hoped that your magazine will place before the public the viewpoint of the industrial diamond industry as expressed by this Association. Thereby there might be some mitigation of the trouble caused by articles similar to the one that appeared in your December issue.

Athos D. Leveridge
Executive Manager
Industrial Diamond Assoc.
of America, Inc.

Cathodic Protection With Zinc Anodes*

Cathodic protection with zinc has continued since its first known use for this purpose on copper-sheathed wood-hulled ships. It was then used on steel ships to reduce the effect of the galvanic couple between hull steel and bronze propellers, which corrodes the hull at the stern of the ship. Protection of

(Continued on p. 174)

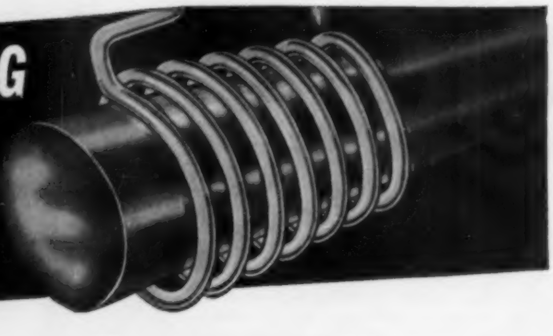
*Digest of "Sound Applications for Zinc Anodes", by A. W. Peabody, a talk presented at the Thirty-Sixth Annual Meeting of the American Zinc Institute, St. Louis, Mo., April 21, 1954.


READ
how you can benefit by JESSOP'S great product variety
Hopes for the future notwithstanding, Jessop lays no claim to being the largest specialty steel maker in America, but careful check shows it to be the most diversified. We produce the greatest variety of special steel products, shapes and sizes available anywhere. There's a profit story in this for Jessop and for you, too. We profit by spreading ourselves across a greater segment of industry. Like a modern investment trust we avoid the ups and downs of vertical markets. Our current sales success proves the point. You can profit if you come to Jessop for more of your requirements and obtain the service and delivery advantages that single-source purchasing affords. What's more, you'll enjoy doing business with the Jessop team . . . aggressive men eager to earn their salt by helping you in your business. Check the list on this page and pick more products to buy from Jessop. You'll be glad you did.
Products
STAINLESS STEELS
HIGH SPEED STEELS
NON-MAGNETIC STEELS
HIGH SPEED TOOL BITS
HEAT RESISTING STEELS
STAINLESS-CLAD PLATES
TOOL STEELS FOR SPECIAL PURPOSES
CARBON AND ALLOY STEELS
CAST-TO-SHAPE TOOL STEELS
HIGH SPEED AND ALLOY SAW STEELS
TEMPERED AND GROUND STRIP STEEL
COMPOSITE HIGH SPEED STEELS
STAINLESS AND HEAT RESISTING CASTINGS
COMPOSITE DIE STEEL SECTIONS
PRECISION GROUND FLAT STOCK
DIE STEELS—HOT AND COLD WORK
JESSOP
STEEL COMPANY · WASHINGTON, PENNSYLVANIA

YOU CAN HEAT *ANYTHING*

FROM A NEEDLE . . . TO
A TURBINE SHAFT

FASTER and BETTER



WITH **Lepel**

HIGH FREQUENCY
Induction
HEATING UNITS

BRAZING
Permits widest choice of silver or copper brazing alloys from lowest to highest melting points. Ideal for brazing carbide tips.

HARDENING
Heat localized exactly where wanted at desired temperature. Ideal for gears, cams, bearing surfaces, cutting tools and other areas that are subject to wear.

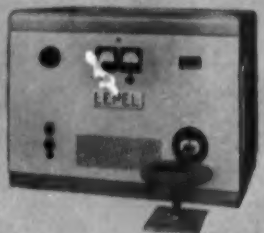
SOLDERING
Speedily and neatly performs intricate soldering applications with or without the use of preformed rings.

ANNEALING
Ideal for annealing, stress-relieving, normalizing or preheating selected areas.

MELTING
Readily melts quantities of ferrous and non-ferrous metals in either graphite or ceramic crucibles.

The Lepel line of induction heating units represents the most advanced thought in the field of electronics as well as the most practical and efficient source of heat yet developed for industrial heating. With a background of half a century of electrical and metallurgical experience, the name Lepel has become the symbol for quality in induction heating equipment embodying the highest standards of engineering achievement, dependable low cost operation and safety.

If you are interested in the application of induction heating you are invited to send samples of the work with specifications of the operations to be performed. Our engineers will process these samples and return the completed job with full data and recommendations without any cost or obligation.



2½ KW INDUCTION HEATING UNIT

30 KW INDUCTION HEATING UNIT

100 KW INDUCTION HEATING UNIT

LEPEL Electronic Tube GENERATORS
1 KW; 2½ KW; 5 KW; 10 KW; 20 KW; 30 KW; 50 KW; 75 KW; 100 KW.

LEPEL Spark Gap Converters
2 KW; 4 KW; 7½ KW; 15 KW; 30 KW.

All Lepel equipment is certified to comply with the requirements of the Federal Communications Commission.

WRITE FOR THE NEW LEPEL CATALOG . . . 36 illustrated pages packed with valuable information on high frequency induction heating.

LEPEL HIGH FREQUENCY LABORATORIES, INC.
55th STREET and 37th AVENUE, WOODSIDE 77, NEW YORK CITY, N. Y.

NOTHING LIKE A REFRESHING DIP . . . and when unplated Vaco Screwdrivers take this dip in Cities Service Anti-Corrode, they're fresh for the next 12 months . . . completely protected against rust and corrosion. Brand new finish, brand new sales appeal. Vaco operates world's largest plant exclusively for manufacturing of screwdrivers.

Screwdrivers take bath that lasts a year!

Bath in Cities Service Anti-Corrode Protects Vaco Screwdrivers Against Rust for 12 Months

The Vaco Products Company of Chicago, Illinois operates the world's largest plant devoted exclusively to manufacturing screwdrivers. Obviously, they cannot afford rust . . . whether screwdrivers are in storage or en route to a customer . . . this is particularly true of special orders for those blades which are not plated.

That's why Vaco uses Cities Service Anti-Corrode #27 on these special order blades. They've found this unusual product prevents rust during transportation and storage.

Whether you're concerned with storage, protection en route or product display, you'll find Cities Service Anti-Corrodes the ideal rust preventives for your business, too. For information, contact your nearest Cities Service representative or write Cities Service Oil Company, Sixty Wall Tower, New York 5, N. Y.

CITIES SERVICE
QUALITY PETROLEUM PRODUCTS

Cathodic Protection . . .

the entire steel hull is a relatively recent development. Magnesium galvanic anodes have been favored in recent years as being more satisfactory than zinc for ship protection. However, zinc is still a competitive product when it is of the right grade and correctly used.

The purity of zinc used in anodes affects their performance in sea water. Anodes of ordinary grades of zinc will at first discharge current and provide protection but as the current discharge consumes the zinc, it becomes covered with a dense corrosion product that prevents the flow of current and the anode becomes ineffective until the corrosion products are scraped away. If the zinc anodes are of Special High Grade zinc with the iron content, particularly, not above 0.0015%, they will give satisfactory protection, since corrosion products that form are porous and of sufficiently low electrical resistivity to cause no appreciable reduction of current output during their service.

In ship protection service, zinc anodes are used to protect the painted hull plates, propellers, condenser water boxes, salt-water tanks, and similar applications. In the protection of painted steel surfaces, it is important to avoid excessive cathodic potentials, otherwise blisters may form in the paint film. Zinc is well suited in this respect since the protective potentials are inherently limited to values that can be tolerated by ship paints.

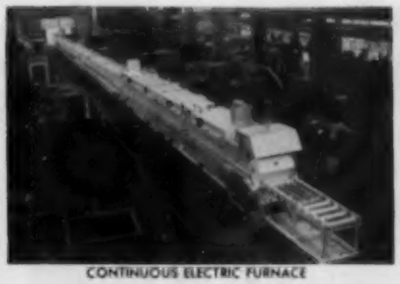
According to the speaker the potential use of zinc anodes for ship protection is large and has not been completely developed. The biggest factor working against zinc is the record of spotty past performance because impure metal and inadequate installation methods were often employed.

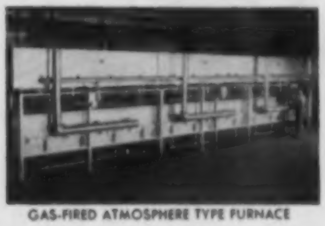
Although the answers to most difficulties – such as obtaining good electrical contact between structure and anode, placement of anodes, and amount of current impressed on them – are now known, intensive re-education of the shipping industry will be required if zinc is to maintain its competitive position in this application.

Steel structures at shipping termi-

(Continued on p. 176)


AUTOMATIC ROLLER GRID FURNACE


CONTINUOUS ELECTRIC FURNACE


GAS-FIRED ATMOSPHERE TYPE FURNACE

BIG ONES


AUTOMATIC ROTARY HEARTH FURNACE

ALUMINUM BILLET HEATER


CONTINUOUS BRAZING PRODUCTION LINES


CONTINUOUS ROTARY RETORT FURNACE


CONTINUOUS CONVEYOR FURNACE


AUTOMATIC HEAT TREATING MACHINE


CONTINUOUS VITREOUS ENAMELING LINE

. . . all field-erected by Lindberg

Maybe you haven't heard the news. Lindberg is now set up to field-erect any type of industrial heating or processing installation. Here are just a few of the large field-erected installations already put up by Lindberg. More are being built right now.

You get a complete package deal from Lindberg. Expert engineers consult with you and analyze your needs. Then they plan and design an installation to meet your specific requirements, whether you need a single furnace or a complete production line. And Lindberg will build it for you, right in your own plant.

To get on-the-spot service from an expert Lindberg engineer, just call your nearest Lindberg Field Office (you'll find the number in the classified section of your phone book, or in the Trade Directories).

LINDBERG INDUSTRIAL

LINDBERG INDUSTRIAL CORPORATION

Chicago Plant: 2321 West Hubbard Street, Chicago, Illinois

Los Angeles Plant: 11937 Regentview Avenue, at Downey, California

Field Offices in principal cities. Associate Companies: Lindberg Engineering Company, Chicago • EFCO-Lindberg, Ltd., Montreal • Lindberg Italiana, Milan, Italy

Cathodic Protection . . .

nals such as steel piers, sheet steel piling and piping – all subject to severe corrosion, especially in sea water – are other marine applications of zinc galvanic anodes. A recent example is a pier on steel piling in sea water given cathodic protection with 101 zinc anodes each weighing 250 lb. (a total of over 12½ tons of zinc) and with each discharging approximately 1½ amp. The anode contained impurities of 0.001% each of lead, iron and cadmium, or a zinc purity of 99.997%. This is the first known application in which provisions for cathodic protection were included in the original design for a new pier.

The useful life of the zinc anodes on the pier is expected to be approximately 8 years. At the end of this period, the anodes can be readily replaced and the protection system will continue unimpaired. The initial 12½ tons of zinc installed in anode form is equivalent to galvanizing the 60,000 sq. ft. of submerged steel with a coating of about 7 oz. per sq. ft. of surface. The builders of the pier determined that rather than paint the steel to limit the amount of cathodic protection current it was more economical to leave the steel bare and apply additional cathodic protection.

Fresh water storage tanks can sometimes be very effectively protected with zinc anodes. The level of protection afforded by zinc is particularly beneficial when used in fresh water tanks having painted interior surfaces. Cathodic protection has been used on transmission and distribution piping systems for only a relatively few years, the first extensive use being in 1935. The use of zinc for this application has expanded with the development of backfills that keep the zinc active and with the finding that high purity zinc (Special High Grade) must be used to get consistent results in soil. Zinc has been found to be particularly applicable in low-resistivity soils for bare and coated pipes. It can also be used to good advantage on well-coated piping in high resistivity since the pipe will assume practically the same electrical potential as that of zinc and very little current output will be required from the zinc to maintain potential. J. P.

Causes of Excessive Grain Growth in Extrusions*

THE AUTHOR begins with a fairly detailed discussion of the metal flow patterns in direct and indirect extrusion using examples from Pearson's "Extrusion of Metals" (Chapman & Hall, London) and other published work, supplemented by several original photographs of etched sections of partly extruded aluminum billets. According to Locke, the most common type of flow in extrusion of hard metals (aluminum included) is characterized by a large volume of "dead" metal left around the mouth of the die and along the container wall. One reason for that is the high coefficient of friction in working aluminum alloys which generally enforces complete shear between the inside of the billet and its skin. Also, especially with ferrous metals and copper alloys, the difference of temperature between billet and container is a major factor in promoting skin shear. A duplex structure is associated with this type of deformation, consisting of a heavily worked, structureless outer layer surrounding a core of "fibrous" material. The heavily sheared metal flows into the extrusion along the dead metal in the annular corner zone.

Temperature is a most important factor in extrusion, but the actual temperatures of the billet and of the issuing section may be quite different. Intense heat is developed by friction and deformation work and its redistribution is complex. Depending on the existing temperatures and the rate of extrusion, the emerging metal may be recrystallized completely, partly, or not at all. The rate of recrystallization is small relative to the commercially employed extrusion speeds, and the outer skin may consist of what is in effect cold worked metal. Depending on working conditions, this residual cold work may be equivalent to the critical strain, and the area may subsequently recrystallize with a large grain.

(Continued on page 180)

*Digest of "Exaggerated Grain Growth in Extrusions", by D. H. Locke, *Metallurgia*, Vol. 50, December 1954, p. 268-275.

Grain Growth . . .

The practical methods suggested to eliminate the excessive grain growth were based on the following ideas:

1. To promote ready recrystallization throughout the bar during or after extrusion.
2. To reduce the strain effects below that of the critical value.
3. To extrude (aluminum alloys) at the solution temperature and to quench at the die, so that the metal is held at temperature only a short time after straining and there is not enough time for recrystallization to occur.

The first method is easy to put into practice, except with heat treatable alloys having high recrystallization temperatures. The second has the advantage of producing a pronounced fiber structure associated with high strength in the longitudinal direction. The third method has been employed in England on alloys having nearly the same temperatures for solution treatment and extrusion (Al-Mg-Si and Al-Zn-Mg types). With the duralumin type of alloy, the heat treatment temperature is some 100° F. above the extrusion temperature, and this method is not practical. In Germany, this difficulty was obviated by installing a furnace behind the die to heat the metal to the correct quenching temperature immediately after it leaves the die; however, this does not eliminate the possibility of exaggerated grain growth.

Alloying with manganese, chromium or zirconium raises the recrystallization temperature and it appears that this method is of sufficient promise to warrant a careful study. Another means of combatting grain growth in the outer zone is to reduce the degree of plastic shear by diminishing the friction between the billet and container. Reference is made here to the French patent covering glass lubrication in hot extrusion of steel (see "Considerations for Selecting Steel Extrusions", *Metal Progress* for April 1955, p. 91), to phosphate coating, and to sheathing the billet with pure aluminum or with Al + 1% Zn and Mg + 1.5% Mn alloy jackets.

It is also feasible to extrude at very low temperature, thereby inducing considerable cold work in the

extrusion and so produce a fine grain after heat treatment. This, of course, will require high extrusion pressures and may be impractical. A final suggestion involves the application of a pressure pad with a large clearance. However, the discard would be up to 25% of the billet weight.

The author concludes with a statement that nearly all of the practical remedies advocated are open to criticism. He suggests that progress may result from fundamental studies of the relationship between strain, texture, structure, and grain growth, following the ideas of Hardy and Gow (*Acta Metallurgica*, Vol. 2, May 1954, p. 394).

N. H. Polakowski

Fatigue Strength of an Anodized Aluminum Alloy*

Wrought ⅜-in. round bars of an aluminum alloy, conforming to the specification 3.5 to 4.8% Cu, 1.5% max. Si, 0.3 to 0.6% Mg, 0.4 to 1.2% Mn, 1.0% max. Fe, 0.3% max. Ti, were tested in fatigue after the application of hard wear resistant anodic coatings about 0.001 and 0.002 in. thick respectively, as well as in the uncoated condition. The tests were made by the Wöhler rotating cantilever method, using specimens polished lengthwise by hand, cleaned, and protected against corrosion until anodized. In anodizing, 10% (by volume) sulphuric acid was used with 0.3 amp. per sq.in. at −4 to 0° C. for 20 min. to produce 0.001-in. coatings, and 40 min. for 0.002-in. coatings. This treatment increased the roughness of the surface from 3 or 4 micro-inches to between 50 and 55 μin., and increased the diameter by about 60% of the coating thickness.

Tensile tests showed that the stock used was uniform and of good quality, with the following properties: proportional limit, 38,100 to

*Digest of "The Effect of Hard Anodic Coatings on the Fatigue Strength of D.T.D. 364 B Aluminum Alloy", by E. G. Savage, E. G. F. Sampson and J. K. Curran, Technical Note No. MET 200, June 1954, Royal Aircraft Establishment, Ministry of Supply, London, W.C.2. (Available on loan from National Advisory Committee for Aeronautics, Washington 25, D.C.)

Fatigue of Al . . .

44,100 psi.; yield strength (0.5% offset), 71,200 to 73,900 psi.; tensile strength, 75,700 to 78,400 psi.; elongation, 10.8 to 12.3% (on 4 × area^{-3} in in.); modulus of elasticity, 10.8 to 10.9 × 10^{-6} psi.

The fatigue strength at 10^6 to 10^8 cycles was reduced 35 to 53% by the coatings of either thickness, or from 29,100 to 13,900 psi. at 10^6 cycles, and from 21,500 to around 13,800 psi. at 10^8 cycles. The fatigue ratio at 10^8 cycles was 0.28 uncoated, and 0.15 to 0.18 after coating. The fatigue curves for the coated alloy have a distinct knee at about 10^6 cycles, although without the coating the curve is more gradual, as is normal for aluminum alloys. The work of other investigators is referred to for the fact that hard anodic coatings reduce the fatigue strength of such alloys 20 to 65%.

Reducing the current density toward the end of the anodic treatment might produce a softer coating at the alloy surface and thus reduce the impairment of the fatigue strength, without loss of the desired hardness of the outer oxide surface. It is proposed to determine the value of this suggestion.

G. F. Comstock

Graphitization of Steel*

The nucleation and growth of graphite at 1220° F. was studied in a number of steels. Although this subject has had extensive study in America, the British approached the problem from a new standpoint and the results reported throw additional new light on the mechanism of graphite formation in steels exposed to service conditions below the critical temperature (1330° F.).

Initial work involved a survey of graphite appearance in six steels containing 0.53 to 1.26% carbon heated to 1220° F. in a vacuum. Silicon varied from 0.06 to 0.26%; aluminum from 0.011 to 0.34%; other elements were below 0.06%. Speci-

(Continued on p. 184)

*Digest of "The Graphitization of Steel at Subcritical Temperature", by R. H. Hickley and A. G. Quarrell, *Journal* of the Iron and Steel Institute, Vol. 178, December 1954, p 337-346.

Graphitization . . .

mens 0.1 in. square by 1 in. long were heated to 1740° F. in vacuum and quenched to martensite before reheating to 1220° F. in vacuum for periods of 11 to 20 days; heating was done in evacuated and sealed silica tubes ¾ in. in diameter. After this test only two of the samples exhibited a slight trace of graphite. These results are greatly different from American results on similar steels when heating was done in air.

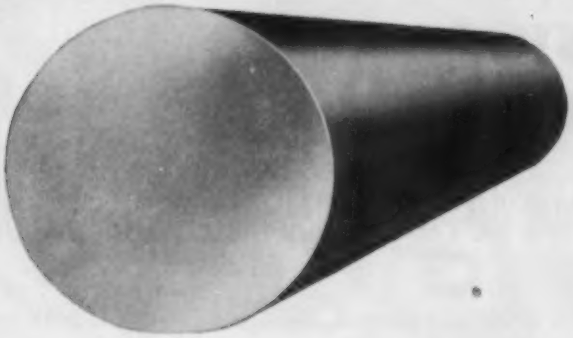
Five of these same steels were treated as before by quenching from 1740° F. to martensite; five other samples were annealed in vacuo at 1740° F. and cold worked to an 80% reduction in thickness. These specimens were then heated in vacuum for 3 months. Under these conditions the amount of graphitization varied from 0 to 95% in the quenched samples and 0 to 90% in the cold worked samples. The degree of graphitization was determined by a modified Eggertz method, in which the decarburized surface was machined off and a 0.2-g. sample was dissolved in cold nitric acid (1.2 specific gravity). The solution was then heated in a boiling water bath for 10 min., rapidly cooled, and filtered. Examination of the clear solution in a photometric absorptiometer gives the combined carbon within ± 0.015% C, whence the graphitic carbon is determined by difference.

The considerable difference in the amount of graphite formed by heating in vacuum as compared to the larger amount reported by other investigators for heating in air or molten lead caused the authors to heat two of these five steels for 20 days in molten lead at 1220° F. One of the samples showed as much graphite in 20 days in molten lead as it had after 3 months in vacuum. The other sample, which had not exhibited any graphite in any previous test in vacuum, also contained no graphite after 20 days in molten lead. This steel was not deoxidized; silicon content was 0.05%, aluminum was 0.011%.

A further survey of the effect of atmosphere on the rate of graphitization was made by heating the same five steels for 20 hr. at 1220° F. in five different atmospheres; namely,

(Continued on p. 186)

When you make hollow parts . . .



Why use bar stock?

start with seamless tubing

Save steel, machining time!

WHY bore out bar stock to make hollow parts when Timken® seamless steel tubing lets you start production with the center hole already there? You don't waste steel and you save machining costs, too. Finish boring is often your first production step. Screw machine stations can be released for other jobs. So you add machining capacity without adding machines. And you save money because you pay only for the steel you use.

Our engineers will save you even more money, too, by studying your problem and recommending the most economical tube size for your hollow parts jobs, guaranteed to clean up to your finished dimensions.

You also get fine forged quality in Timken seamless steel tubing. The piercing process by which it is made is basically a forging operation.

It gives the tubing a uniform spiral grain flow for greater strength, and a refined grain structure which brings out the best in the quality of the metal. The Timken Company's rigid quality control keeps this quality uniform from tube to tube and heat to heat. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

YEARS AHEAD — THROUGH EXPERIENCE AND RESEARCH

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING

Graphitization . . .

oxygen partial pressure of 0.20, 0.50, 7.10, 15.9, and 75 cm. In these tests the rate of graphite formation was at a minimum for the lowest partial oxygen pressure. Two samples with very low contents of aluminum and silicon were not affected by the amount of oxygen pressure. Steels with more aluminum and silicon (over 0.04 and 0.15% respectively), which graphitized more readily in vacuum, showed rapid graphite formation in 2 to 8 days at all partial pressures of oxygen. These results indicate a definite relation between the amount of silicon and aluminum in steel and oxygen in the furnace atmosphere. The more rapid rate of graphitization in atmospheres containing oxygen and the increased amount of nucleation of graphite led to the conclusion that some foreign nuclei were forming in the steels in the presence of oxygen.

Since both aluminum and silicon have long been known to promote graphitization, four steels containing 0.85% carbon, less than 0.08% silicon, and 0.072, 0.24, 0.79, and 2.35% aluminum were melted in 15-lb. ingots in a high-frequency furnace. One iron-carbon alloy containing no aluminum or silicon was also made by soaking pure iron rods at 1725° F. in an atmosphere of hydrogen and methane. Three additional heats containing no aluminum, 0.86% carbon, and silicon varying as 0.41, 0.83, and 1.64% were also melted in the high-frequency furnace. These eight specimens were then exposed at 1220° F. in oxygen atmospheres with partial oxygen pressures of 0.2, 0.5, 7.1, 15.9, 75 cm., as before.

Under these test conditions graphitization started within 3 hr. in some samples and was almost complete in all samples in 2 days. The results show that at the 0.10% level aluminum is much more potent than silicon in causing graphitization but, for concentrations of about 1.0%, aluminum is only about three times more effective than silicon. In these tests the greater the rate of graphitization the more numerous are the graphite nuclei observed in the microscope. Excellent micrographs of the distribution and size of graphite formed under various test cycles are contained in the paper. Additional tests

(Continued on p. 188)

Do you have a TOUGH
CORROSION-RESISTANT CASTING
PROBLEM?

that needs a solution for your product design?

Problem—Do you require quality corrosion-resistant castings that: are also resistant to high fluctuating temperatures; machine freely; require a highly polished surface; are true to pattern; stand high pressures and high loads; are stabilized; are of large size, small size, intricate shapes; have high resistance to galling or seizing; are non-magnetic?

Solution—Consult with Waukesha—specialists in quality corrosion-resistant castings to meet the design requirements of the leading products in many industries.

Why Waukesha—Experience: Waukesha has over forty years' broad experience in providing quality-controlled, corrosion-resistant castings to industry. This hard-earned know-how and specialized craftsmanship is at your disposal. **Research:** A modern laboratory guarantees castings metallurgically engineered to your specifications . . . **created metals** to fit the job . . . precise **custom castings** to help improve your products. **Facilities:** Waukesha can supply your production casting needs on schedule.

We Suggest—that you write, today, for a casting quotation from your blueprints or engineering counsel on your casting design. Informative literature available on request. Waukesha Foundry Company, 5505 Lincoln Avenue, Waukesha, Wisconsin

Waukesha Corrosion-Resistant Casting: Pump impeller for the chemical and processing industries. Metallurgical control of every production step guarantees you quality precision castings.

The Waukesha metallurgical laboratory is available for research on your casting needs.

Waukesha
Foundry Company
WAUKESHA, WISCONSIN

WAUKESHA: *SPECIALISTS IN CORROSION-RESISTANT CASTINGS FOR ALL INDUSTRIES*

Graphitization . . .

and diagrams also show that quenched steels, cold worked steels, and fully annealed steels graphitize at rates which are inverse to the order listed. For example, on one steel tested, the quenched sample completely graphitized in 2 to 4 hr., the cold worked sample in 5 to 10 hr., and the fully annealed sample in 100 to 200 hr. This confirms previous observations reported in the literature.

An extended discussion based on work by Mehl and Zener of both the rate of nucleation and rate of growth of graphite particle size follows. Mathematical expressions for the rate of graphitization and rate of growth of graphite particles as affected by the variables temperature and time are given and discussed in considerable detail.

Conclusions – Studies of graphitization at 1220° F. of 15 plain carbon steels, four high-carbon aluminum steels, three high-carbon silicon steels, and a pure iron-carbon alloy show that graphitization is much slower when the treatment is given in vacuum than if oxygen is present. The more stable steels are sensitive to the partial pressure of oxygen in the atmosphere prevailing during subcritical treatment. The effect of variation in this pressure, in the range 0.2 to 75 cm., is less with increased instability of the steel, and is negligible for the most unstable steels studied. If a steel is quenched to martensite before treatment at 1220° F. it graphitizes much more readily than if previously annealed; cold working as a pretreatment produces an intermediate effect. The presence of metallic aluminum in steels in small quantities, or of silicon in larger quantities, promotes graphitization. The rate of growth of graphite is smaller in aluminum steels than in silicon steels, and still less in plain carbon steels.

A hypothesis has been advanced to account for the effect of aluminum and silicon in promoting graphite nucleation in the presence of oxygen. This suggests that many particles of alpha alumina or of cristobalite are produced when steels containing aluminum or silicon are treated at 1220° F. in the presence of oxygen, these oxides acting as foreign nuclei for graphite. E. C. WRIGHT


When
Your Product
needs a
PUSH...
10
8
8
7
You'll Score Better
with SHARON STAINLESS STEELS
Type 430 Stainless and Galvanite* Coated booklets are available from any Sharon office.
DISTRICT SALES OFFICES: Chicago, Cincinnati, Cleveland, Dayton, Detroit, Indianapolis, Los Angeles, Milwaukee, New York, Philadelphia, Rochester, San Francisco, Seattle, Montreal, Que., Toronto, Ont.
Sharon produces all popular grades of Stainless Steel in large diameter coils for economical fabrication, and with the finest finish available in the industry.
SHARONSTEEL
SHARON STEEL CORPORATION
Sharon, Pennsylvania

Foil From Stainless Steel Powder*

EUROPEAN researchers have shown that soft, ductile aluminum powder could be rolled and densified into foil of high strength and nearly full density. This investigation parallels that work on aluminum and was undertaken to see whether harder powder such as stainless steel could also be fabricated into foil.

All work was done at Sylvania Electric Products, Inc., Atomic Energy Division, using Type 302-B stainless steel powder supplied by Vanadium-Alloys Steel Co. The objective was to produce a dense, strong and ductile foil of stainless steel and to study variables such as the rolling characteristics of the powder, including the effect of roll opening, roll speed and type of powder feed as reflected in density and thickness of the strip produced. Studies were also made of the sintering of the green rolled strip, including variations of temperature and time at temperature. Also included in the program were the effects of re-rolling of the sintered strip, including the effect of number of cold passes on tensile strength, elongation, hardness, preferred orientation, density, thickness and corrosion resistance.

Drawings showing the arrangement of the rolls and feed methods and the sintering furnace are included. Also shown are curves giving the relationships of the processing variables to thickness, green density, sintered density, as-sintered tensile strength, cold rolled tensile strength, elongation, hardness and corrosion rate. Photomicrographs of as-sintered and cold rolled strip are included.

Rolling Procedure – The powder was either dumped into the "V" formed by two parallel 6 × 6-in. rolls to provide heavy feed, or fed into the rolls from hoppers of various sizes maintained at different distances from the rolls to give controlled feed. By variation of rolling conditions to apply pressures be-

(Continued on p. 192)

*Digest of "Rolling 18-8 Stainless Steel Powder Into Strip", by S. Storcheim, J. Nylin and B. Sprissler, Report No. SEP-161, published by the Technical Information Service, U. S. Atomic Energy Commission, Oak Ridge, Tenn.

Stainless Foil . . .

tween 80,000 and 152,000 psi., green strip densities up to 6.98 g. per cc. were obtained. It was found that the density of the green strip decreased as rolling speed increased within the range of 10 to 40 rpm. The increase of roll speed in this range caused an increase in thickness of the green strip from 0.015 to 0.05 mil. Although the effect of variations in powder feed was rather small, density decreased with increasing width of the feed hopper.

Sintering Procedure – Sintering was done in dry hydrogen having a dew point of −62° C. at various temperatures and times at temperature. As temperature increased from 1080 to 1280° C., density increased almost linearly from 5.55 to 7.10 g. per cc. Sintered density increased linearly from 6.29 to 6.59 g. per cc. as sintering time was increased from ½ to 24 hr. with temperature remaining constant. The increased density resulting from increases in sintering time and time at temperature increased tensile strengths up to 91,000 psi. for a 24-hr. sintering time at 1300° C. This strength was accompanied by an elongation of 21%.

Cold Rolling – In the study of effects of re-rolling it was discovered that density reached a peak of 7.65 g. per cc. on the third cold reduction in a cycle of a maximum of 5 reductions. Under the conditions of the test very little change in thickness resulted in up to 5 reductions. Annealing the cold rolled sintered specimens did not materially increase density. The ultmate tensile strength for the re-rolled sheet given 5 cold passes was a maximum of 132,500 psi. in the longitudinal direction. The ultimate tensile strength in the transverse direction was 104,500 psi. Annealing lowered the tensile strengths to the range of 81,000 to 91,500 psi. Elongations obtained after annealing of the re-rolled strips varied from 1 to 30% and increased with increasing cold passes up to 5. Specimens tested in the cold worked condition showed a maximum of 3% elongation.

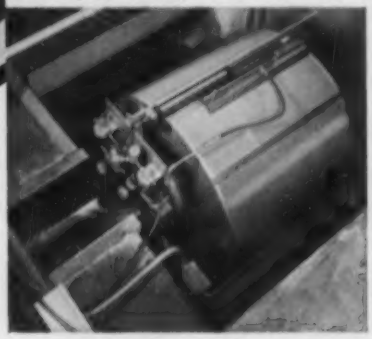
Corrosion Resistance – The corrosion rates of the powder metallurgy strip in water at 68° F. at 500 hr. were approximately the same as corrosion rates for strip prepared from

(Continued on p. 194)

the MURRAY WAY MODEL 10 FILTER

THE AUTOMATIC INDUSTRIAL FILTER THAT RECLAIMS YOUR PRODUCTION DOLLARS

Contaminated coolant enters Model 10 directly from source.



Standard Model 10 with 200 mesh screen removing abrasive grindings from 55 viscous coolant oil in belt grinding operation.

AUTOMATIC—The Murray-Way Model 10 Industrial Filter automatically rotates fresh filtering area into position while simultaneously ejecting the contaminant.

SELF-CLEANING—The permanent filter screen, made in eight sections and screw mounted, is kept clean by the air knife thus giving maximum filtration at all times.

ECONOMICAL—Elimination of costly throw-away media saves you money.

COMPACT—The Murray-Way Model 10 gives you unusually large filtering capacity in proportion to area occupied.

AMAZINGLY ADAPTABLE—The Murray-Way Model 10 Filter may be used as an individual machine unit or as a central filtering station for many units. Capacity may be increased by adding filters in tandem separately or in the same tank.

LARGE SCREEN SELECTION—We can supply filtering screen material and size of screen opening in monel, stainless steel, brass or bronze to meet your requirements.

For Complete Technical Details—Write For Bulletin F-5301

MURRAY WAY

THE MURRAY-WAY CORP.
POST OFFICE RACK 180 • BIRMINGHAM, MICH.
Automatic Polishing, Buffing, Grinding, Filtering Equipment

Stainless Foil . . .

solid material, being 0.280 and 0.300 mg. per sq. cm. respectively. The maximum corrosion rate for the powder metallurgy strip was 0.720 mg. per sq. cm. for the cold worked strip at 1000 hr. compared with a rate of 0.320 mg. per sq. cm. for annealed strip.

Conclusions – The foil produced by rolling stainless steel powder was of high density, high tensile strength, good ductility and good corrosion resistance. The data obtained for various conditions of green rolling, sintering and cold rolling make it possible to predict the techniques and equipment necessary to fabricate thicker or thinner strips than those actually made. This new method of rolling foil from metal powder is feasible and satisfactory for both soft and moderately hard powders.

W. L. Batten

Welding Methods and Acid Resisting Alloys Used in Germany*

The first article is on the new developments in welding equipment and welding fabrication. It is primarily a review of progress in welding and covers the submerged-arc welding practices and the economies that can be obtained from the higher metal deposition this process offers over manual welding with covered electrodes. The article also deals with Heliarc and sigma welding and refers to practices used in the United States for these as well as for inert-gas welding. The application of sigma welding to stainless steel is pointed out and reference is made to inert-gas spot welding but no information is given on this subject. Mention is made of stud welding, which is very similar to the Nelson stud welding method employed extensively in this country.

(*Continued on p. 196*)

*A review of (1) "Recent Welding Developments in Apparatus and Tank Construction", by H. Engstler; (2) "The Acid Resistance of Low-Nickel, High-Chromium Alloys With Molybdenum and Copper Additions", by W. Tofaute and H. J. Rocha; (3) "Welding in Modern Shipbuilding", by K. Holand, *Technische Mitteilungen Krupp*, Vol. 3, June 1954.


No matter what you make H&H Brass and Copper tubing will help make it better
From automobile radiator inlet and outlet tubes to parts for water faucets, there is an H & H seamless brass and copper tube with an O.D. and wall thickness that's exactly right for the purpose. H & H seamless brass and copper tubing is available for fabrication and redraw in range of ⅛" O.D. to and including 1½" O.D., wall thickness range, .010 to and including .065. 70/30; 80/20 and 85/15 alloys; also copper.
Originators and Sole Makers of METALFLO Tubing
Expect the BEST brass and copper products from
H & H Tube
AND MANUFACTURING COMPANY
256 N. Forman Avenue, Detroit 17, Michigan • Offices from Coast to Coast
METALFLO
LOCKSEAM
COIL STRIP
AND
SEAMLESS TUBING
TUBULAR PARTS

Welding Methods . . .

The reference to a new development in Germany with regard to the use of a ceramic quartz-containing material as a backing for welding from one side, is for welding circular seams in pipe and also for pressure vessels of small diameter. There are no details describing it or information on its composition.

This first paper also includes a description of powder cutting equipment for gas cutting of stainless steel and nonferrous metals. The summary points out the importance of inert-gas welding and that it may increase in application and importance. It is also indicated that because of high labor costs, automatic welding is definitely increasing and that submerged-arc welding particularly is more economical than manual welding.

The second article gives considerable information on a large variety of alloys containing nickel-chromium, molybdenum and copper with regard to their corrosion resistance in sulphuric acid and nitric acid. A special test is described for determining the passivity characteristics of these alloys. The magnetic and mechanical properties of the alloys are given in a tabulation.

Corrosion data for these alloys without molybdenum, in boiling nitric acid, are given. The effect of chromium concentration on the passivity characteristics in surphuric acid is also described. The effects of nickel and molybdenum content are discussed.

A summary of this paper indicates that alloys containing from 20 to 30% chromium and from 0 to 10% nickel with 0 to 3% molybdenum and 0 to 3% copper were examined for their mechanical, magnetic and corrosion resistance properties in nitric and sulphuric acids. The results indicate that the alloy containing from 23 to 30% chromium, with a low nickel content of approximately 2½%, has excellent passivation characteristics in sulphuric acid and in some degrees is better than the well-known 18-8 type stainless steel alloys. The addition of 2% molybdenum and 1% copper revealed excellent mechanical properties and increased corrosion resistance with respect to the passivation character-

(Continued on p. 198)

NOW AVAILABLE IN CLOTH-BOUND EDITION

Metals Handbook
New 1954 Supplement

Order now a copy of the 1954 Supplement bound in red cloth to match your 1948 ASM Metals Handbook. The Supplement contains recent, authoritative information on all these subjects:

- **Carbon and Alloy Steels**
- **Tool Steels**
- **Stainless Steels**
- **Heat-Resisting Alloys**
- **Nodular Cast Iron**
- **Aluminum**
- **Copper**
- **Magnesium**
- **Titanium**
- **Engine Metals**
- **Stress Concentration**
- **Shot Peening**
- **Ferrous Castings**
- **Brazed Joints**
- **Heat Treating**
- **Metal Cleaning**
- **Press Forming**
- **Machining**
- **Powder Metallurgy**
- **Steel Melting**
- **Nondestructive Inspection**
- **Metallography**

This handsome 200-page volume contains 24 articles supplementing the 1948 ASM Metals Handbook. Prepared by 22 ASM technical committees, it has 326 illustrations, 155 tables. It makes a worthy addition to your technical library, one you'll refer to often.

For complete details of contents, see your July 15, 1954, issue of Metal Progress . . . which contains all the articles now being offered in this cloth-bound edition. Price is $4.00 to ASM members, $5.00 to nonmembers.

American Society for Metals
7301 Euclid Avenue, Cleveland 3, Ohio

Rush me a copy of the cloth-bound 1954 Supplement to the ASM Metals Handbook.

Name________________________________

Company________________________________

Address________________________________

City________________ State__________

Member of____________________ ASM Chapter

☐ $4.00 enclosed—ASM member ☐ Bill me
☐ $5.00 enclosed—non-member ☐ Bill my company

Welding Methods . . .

istics; in some ways this is superior to the 18-8 type of alloys.

The third article pertains to welding in modern ship construction and is primarily devoted to the use of subassembly construction in shipbuilding, a development which started in the United States during the last war. Economy of using subassemblies in the fabrication of a welded ship is clearly indicated and apparently the German practice today follows this trend. The summary of this article indicates that in modern ship construction, welding has replaced practically all riveting. It emphasizes the importance of employing ductile material, which is described as insensitive to crack propagation, and proper design in construction and the importance of using approved welding procedures.

J. J. CHYLE

Test for Screening Cast Stainless Alloys*

THIS PAPER describes a practical application of the procedure set forth by M. A. Streicher, "Screening Stainless Steels From the 240-Hour Nitric Acid Test by Electrolytic Etching in Oxalic Acid", *ASTM Bulletin*, February 1953, p. 35 (reported in *Metal Progress* for July 1954, p. 166). Steels which are susceptible to intergranular attack can be segregated from those immune to such attack by the characteristic microstructures of the former. The investigation, sponsored by the Alloy Casting Institute, revealed the microstructures which are obtained with the electrolytic oxalic acid test. Cast steels of the CF-8 and CF-8M grades were used, in both the annealed condition (quenched in water from 2000° F.) and the annealed and sensitized condition (sensitizing at 1200° F. followed by a water quench).

The test involves polishing through

(Continued on p. 200)

*Digest of "Electrolytic Etching in Oxalic Acid Used to Screen Cast CF-8 and CF-8M Stainless Steels From the 240-Hour Nitric Acid Test", by F. H. Beck, N. D. Greene, Jr., and M. G. Fontana, *ASTM Bulletin*, January 1954, p. 68-71.

Screening Test . . .

500-grit papers followed by electrolytic etching for 1½ min. at a current density of 1 amp. per sq.cm. of surface area in a solution of 10% (by weight) oxalic acid in water. Photomicrographs at 250 × of etched specimens showed one or more of the following structures:

1. Complete ditching of grain boundaries.
2. Heavy etching of interconnecting ferrite stringers.
3. Random pitting.
4. Slight etching around ferrite pools.
5. Little or no etching of grain boundaries.

Only those cast stainless steels showing the structures described under 1 and 2 above would be considered to require the complete 240-hr. boiling 65% nitric acid test.

In this series of tests duplicate specimens were prepared from each casting submitted to the screening test. One specimen was subjected to the boiling nitric acid test (A.S.T.M. Specification A 262-52 T) and the other specimen was given the electrolytic oxalic acid test as described above. Tabulated data are presented which are typical for a number of tests and serve to illustrate the reliability of the screening procedure. Tests were also made using higher and lower current densities in etching with compensations in the time. These showed that although improvements in the appearance of the microstructures could be achieved by changing the etching conditions from those proposed by Streicher, these changes did not result in any great advantage. It is desirable to have standard etching conditions for both wrought and cast stainless steels.

Among the specimens examined were some obtained from solution treated and quenched material. This material would normally show low corrosion penetration rates for nitric acid and would pass this test. Other specimens had been deliberately sensitized. There was complete correlation between the screening tests and the more exhaustive 240-hr. boiling nitric acid test. Thus the screening procedure with the shorter electrolytic etching avoids the necessity for the boiling nitric acid test

(Continued on p. 202)

Screening Test . . .

and only those materials which fail the etching test need be subjected to the 240-hr. test.

Conclusions – An electrolytic etching screening test can be used for cast alloys CF-8 and CF-8M. Only those cast stainless steels showing structures described under 1 and 2 above need be subjected to the 240-hr. boiling nitric acid test. All the other microstructures are representative of steels having acceptable corrosion penetration rates in the nitric acid test. Evidence of pitting is likely to be observed in the microstructures, but pitting alone is not considered a determining structure for screening cast stainless steels.

R. L. Anderson

Factors Affecting Microcharacter of Metal Surfaces*

THE SURFACES of single and polycrystals of metals show characteristic changes in structure under the influence of various factors that fail to remove noticeable amounts of metal. Thus, if a polycrystalline metal that has been subjected to mechanical working is heated in a vacuum at a high temperature, the traces of the working disappear and sharp boundaries between the separate crystallites become visible. As a result of a reaction that is catalyzed by the metal, the same phenomena occur at temperatures several hundred degrees centigrade below the temperature of "thermal etching".

On prolonged heating, one observes grain coarsening and the characteristic ledge-structure.

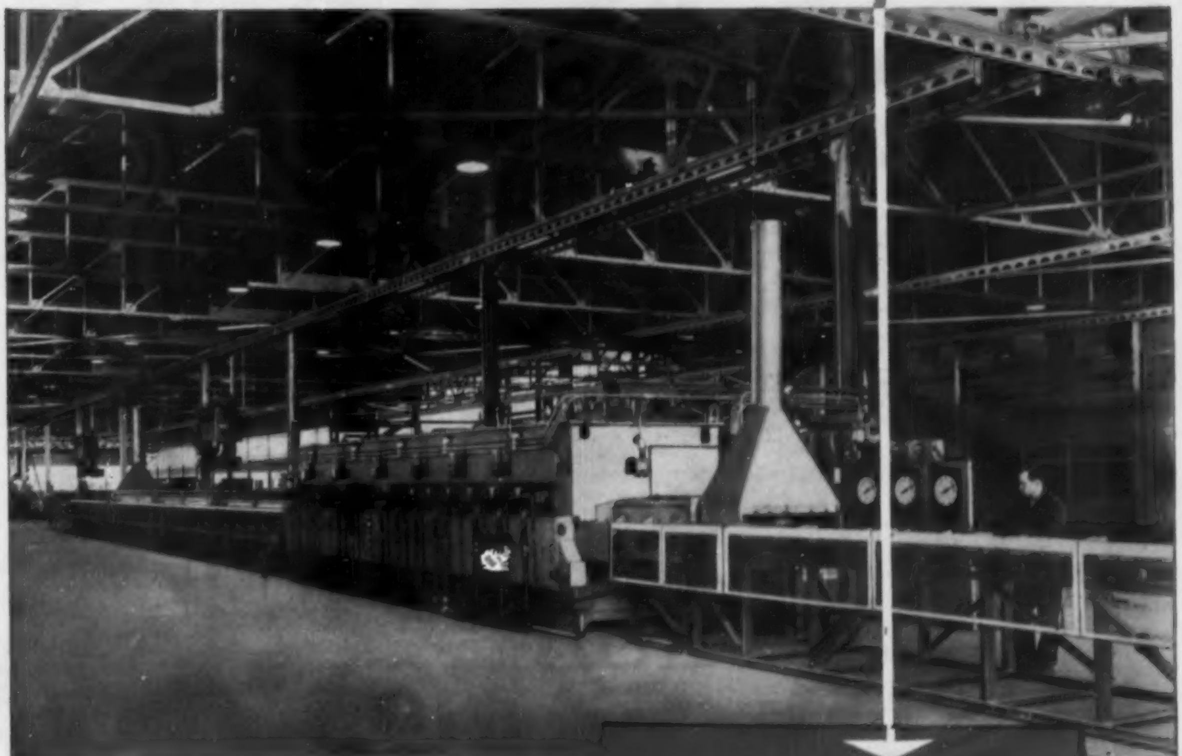
The latter structure has been the subject of many studies using the optical microscope and these have led to the belief of a block substructure with a linear dimension of 5000 to 8000 Angstroms. Electron microscopic studies of the surface changes produced by chemical proc-

(Continued on p. 204)

*Digest of "Changes in Metallic Surfaces Produced by Chemical Processes and by Heating", by S. Z. Roginskii, I. I. Tret'yakov and A. B. Shekhter, *Doklady Akademii Nauk SSSR*, Vol. 91, 1953, p. 1167-1169.

DREVER

ROLLER HEARTH *Bright-Annealing* **FURNACES**



12

FOR

CARBON and ALLOY STEEL PARTS, BARS or TUBING

Shown above:

Controlled Atmosphere Furnace
Radiant Tube, Gas-Fired
Capacity, 3,000# /hour
Alloy Tubing 1/8" O.D. to 2½" O.D.
Overall, 176 ft. long x 7'-6" wide

Installed at plant of Sawhill Tubular Products, Inc.

Also Available:

Gas or Electric Furnaces for Stainless Steel Annealing with or without Controlled Atmosphere

DREVER CO.
Red Lion Rd.
& Philmont Ave.
Bethayres, Pa.

Metal Surfaces . . .

esses and by heating have now revealed new characteristics of the processes involved.

In addition to the block structure previously observed using the light microscope, detailed studies with the electron microscope have revealed shelf or terrace-like structures of significantly smaller width and height, often in the form of typical growth formations. Thus, when palladium was heated at 1000° C. (1830° F.) in vacuum, lamellar protuberances with a spacing of 500 A. appeared on the surface. Also, a lamellar structure with a spacing of 200 to 300 A. was observed on platinum.

The sizes of the units of substructure are thus an order of magnitude smaller than described by L. Graf. Also, Graf's estimate of the depth and width of grain-boundary depressions was much larger than the present value of about 30 A.

The fine structures described above were not the result of local overheating, since an entirely different "crater" structure was produced when the surface reaction was more rapid. At reaction rates that eventually produced the usual terraces, the initial structure was more of a rounded "hills and valleys" kind having about the same dimensions.

The three factors that seem to determine the type of surface structure that develops are thermodynamic, kinetic and chemical. The thermodynamic free energy can approach a minimum by: *(a)* eliminating any worked surface layer; *(b)* replacing crystal faces of high surface energy by those of lower energy; *(c)* coarsening of grains through recrystallization. A powerful thermodynamic factor is the specific chemical adsorption of foreign substances, such as oxygen on platinum. Gomer has shown that this adsorption occurs to various degrees on different grains and that a grain experiencing strong adsorption has a minimum surface energy. Thus, a surface may undergo a reorganization in the presence of a certain medium and then reverse this change when the medium is removed.

The kinetics of the surface reactions being considered would appear to involve surface diffusion, the

(Continued on p. 206)

This You'll Like!

If You Appreciate Functional Alloys of Brains and Metal

At last, a road report on the MERCEDES, Masterpiece; it was WORTH waiting for! Had the engineering genius at Stuttgart been extended to insure considerate, intelligent handling of enthusiastic customers (who paid $1000.00 deposits on irresponsible delivery promises, got dilatory "stalls," and price hoists), the venerable prestige of a famous name would have even wider U. S. acceptance.

For the second* time in automotive history a world famous producer has shot-the-works, wrapped up all of the proven advanced stuff in one potent package of Design - Process - Metallurgical - Production-PERFORMANCE **Achievement.** *(First: The 1926 Grando Prix Buggati, 7800 RPM 130 MPH, with which we once towed a Stutz of twice its weight nine miles faster than it would run.)

The Mercedes-Benz 300 SL; a 183 cu. in. motor delivering 240 BHP, **at the clutch** at 6200 RPM, 4 wheel independent suspension, fuel injection, "Turbine-cooled" power brakes, noiseless streamlining (including underpan), controlled thru-flow ventilation, 2-turn steering, oil cooling; all this in a 2500 lb. (curb wt. with 32 gals. gas) luxurious and comfortable "Business Coupe" that wheels at, and accelerates above, 150 MPH (0 to 60 MPH under 6 sec.).

No comparable verity of "That which is truly functional is truly beautiful" rides rubber.

This 300 SL Coupe is substantially identical (except that it has more power and minor refinements) to the 1952 world champion 300 SL race cars, and the 1,-2,-3, winners of the Mexican Transcontinental Road Race. It compares to the production Jaguar as the "Thunderbird" compares to the 1936 Ford. (Incidentally, our "Jag", first Chicago Show model we reported in M. P. as "A Duchess in dirty linen," a mainly well engineered job, executed in sloppy detail, has since been "modified" and is relegated to towing the Bolus stressed-skin Dural trailer, at over 100 MPH.)

Tom Franks, G. A. V.-P., and Don Hutchins, G. A. Detroit Manager who have been ground-hopping a mate to the above car (but silver with magnesium "knock-off" racing wheels), report that our friends have been queing-up for rides like they did for rides in our airplanes at the 1920 (or was it '21?) A. S. M. (nee American Society for Steel Treating) Indianapolis Metals Show, and for rides in our amphibious "Ducks" in the six-foot surf off the Convention Hall at Atlantic City.

"SAFETY," remarked a top Detroit Engineer, "rather than SPEED, is the 300 SL's outstanding asset. It can stop on a dime **and leave 4c change.** You sit **in** it, not **on** it, driver and car **both** corner without sliding." A designer, credited with winning one heat of the "CHEAP" car length race "by a head-light eyelash vs. a pregnant tail light" was pleased, but somewhat embarrassed, when he remarked, "Maybe some customers will pay more to leave off the chromed pot-metal 'Schmaltz' and the Jacobs-coat moron-bait. Oh, by the way," he continued, "have any of those Studys wearing the pilfered Mercedes three-point star, crawled under a truck when they spied the pedigreed article?" Tom swears that a gutteral voice, **coming out of the nose grill,** remarked, "ACHTTT! Phooey! How Loewy khan dey get?"

It is gratifying that truly ENGINEERED alloys of Brains and Metal, in cars, planes, and even high-temperature heat treat tooling, attract "Kindred Spirits" **in mutual loyalty to the Spirit** of WORK WELL DONE. Men who **instinctively** turn from mediocrity, who **know** that INVESTMENT in Quality, Dependability, insures PERFORMANCE and Long SERVICE, in machines, alloys, or shoes, **seldom lose.** Buyers of the 1926 Buggati could have made a cash profit on their investment at any time since purchase, but the dividends in SUPERIOR PERFORMANCE were the **principal return.**

The 300 SL will probably cost less per year of service, and depreciate far less in five or ten years of RICHLY SATISFYING driving experience, than any other transportation investment. Such is the recognition, by **discerning** men, of the basic integrity of superior concept, execution, and performance. Attainment of such recognition separates the leaders from the following herd, IT is their **priceless reward.**

On request, we will be glad to send reprints of article on the 300 SL by famed authority Laurence Pomeroy F.R.S.A. M.S.A.E. appearing in "THE MOTOR."

AN "ADDITORIAL" BY PRES. G. A. CO.

Mercedes-Benz—300 SL. H. H. Harris and Ralph Van Deventer

Mercedes-Benz 300 SL	
Engine dimensions	
Cylinders	6
Bore	85 mm.
Stroke	88 mm.
Cubic capacity	2,996 cc.
Piston area	52.8 sq.in.
Valves	Inclined I o.h.c.
Compression ratio	8.55 to 1
Engine performance	
Max power	240 b.h.p.
at	6,000 r.p.m.
B.M.E.P. at peak power	171 lb./sq.in.
B.H.P. per sq.in. piston area	4.55
Peak piston speed, ft. per min.	3,540
Engine details	
Carburetter	Bosch injector
Ignition	Coil Beru 280/14
Fuel pump	Bosch
Fuel capacity	28½ gal.
Transmission	
Clutch	Single plate
Gear ratios:	
Top	3.64
3rd	6.43
2nd	9.14
1st	15.8
Rev.	12.7
Prop. shaft	One piece open
Final drive	Hypoid bevel
Chassis details	
Brakes	Hydraulic and Vac. Servo

Mercedes-Benz 300 SL	
Brake drum diameter	10.25 in.
Friction lining area	256.7 sq.in.
Suspension:	
Front	Coil and wishbone
Rear	Coil and swing axle
Shock absorbers:	
Front	Telescopic
Rear	Telescopic
Wheel type	Bolt-on disc
Tyre size	6.70 × 15
Steering gear	Worm and roller
Dimensions	
Wheelbase	7 ft. 10½ in.
Track:	
Front	4 ft. 6½ in.
Rear	4 ft. 8½ in.
Overall length	14 ft. 8 in.
Overall width	5 ft. 10½ in.
Overall height	4 ft. 1¾ in.
Dry weight	20 cwt.
Performance data	
Piston area, sq.in. per ton	52.8
Brake lining area, sq.in. per ton	256.7
Top gear m.p.h. per 1,000 r.p.m.	24.3
Top gear m.p.h. at 2,500 ft./min. piston speed	105
Litres per ton-mile, dry	3,700

Driving Speeds MPH		1st Gear	2nd	3rd	4th
Axle Ratio	1:342				
	6000 RPM	44.1	75.7	110.5	145.3
	6200 RPM	47.8	82	119.8	157.7
Axle Ratio	1:325				
	6000 RPM	46.8	79.4	115.0	152.8
	6200 RPM	50.5	86.2	125.4	165.8

Engine capable of turning continuously at 6200 RPM. Injection pump automatically corrects for temperature and altitude.

GENERAL ALLOYS COMPANY

405 W. First Street—Boston, Mass., U.S.A.

With offices or representatives in principal cities.

Solicits your inquiries for ENGINEERED HEAT AND CORROSION RESISTANT ALLOY CASTINGS AND FABRICATIONS. Backed by 36 years of experience.

"NO FURNACE IS BETTER THAN ITS ALLOY PARTS."

THE FOOTSTEPS OF GENERAL ALLOYS MARK THE PATH OF AN INDUSTRY

Metal Surfaces . . .

rate of which is increased at higher temperatures. However, other factors, such as compound formation or the presence of an active substance, can also facilitate the reactions.

The third group of factors is connected with chemical impurities of the solid body. These form a film at crystal boundaries and interfere with grain growth and recrystallization. Chemical processes can also affect the thermodynamic factor, for example by changing the phase compositions.

A. G. Guy

Ductility of Chromium at Room Temperature*

A preliminary examination of the factors governing the room-temperature ductility of chromium was made by the Aeronautical Research Laboratories at Melbourne, Australia. This work, done with chromium spectrographically pure, contained, normally, 0.06% oxygen, 0.005% nitrogen and less than 0.005% carbon. The chromium was melted in an argon-arc furnace and then forged, swaged and rolled in protective steel sheaths.

The surface sensitivity of chromium was demonstrated by room-temperature tensile tests on wrought sheet. A maximum tensile elongation of 15% with a corresponding ultimate strength of 74,500 psi. was obtained after electropolishing. Roughening the surface by acid etching or grinding and filing increased the ultimate strengths to 78,500 and 89,000 psi., respectively, but decreased the tensile elongations to values of 11% and 0%, respectively.

Small amounts of nitrogen seriously impair the room-temperature ductility of chromium. Approximately 0.02% nitrogen dissolved in the metal renders it brittle in simple bend tests. Embrittlement by this mechanism occurs upon heating chromium in air or nitrogen at temperatures as low as 1200° F. for

(Continued on p. 208)

* Digest of "A Study of the Room-Temperature Ductility of Chromium", by H. L. Wain, F. Henderson and S. T. M. Johnstone, *Journal* of the Institute of Metals, Vol. 83, December 1954, p. 133-148.

15 times the life in Acid Mixtures

AND STILL GOING STRONG

PROBLEM:

Baskets for submerging alloy steel forgings in hot pickling acids had to be replaced every month because of severe corrosion. The baskets were continually immersed in either 15 per cent hydrochloric acid, aqua regia, 10 per cent nitric and hydrofluoric acids, or 20 per cent nitric acid. All of these acids were at about 140 deg. F.

REMEDY:

The baskets were made of one-inch round bars of HASTELLOY alloy C.

RESULT:

After 15 months' service, three shifts a day, the baskets made of HASTELLOY alloy C are still good.

HASTELLOY alloy C is the most universally corrosion-resistant alloy available today. It has high-strength and is highly resistant to all of the mineral acids. For a copy of a booklet describing HASTELLOY alloys, get in touch with the nearest Haynes Stellite Company office.

HAYNES
TRADE-MARK
ALLOYS

HAYNES STELLITE COMPANY

A Division of Union Carbide and Carbon Corporation

UCC

General Offices and Works, Kokomo, Indiana

Sales Offices

Chicago • Cleveland • Detroit • Houston • Los Angeles • New York • San Francisco • Tulsa

Ductility . . .

periods as short as 2 hr. On the other hand, the ductility of chromium does not appear to be affected by heating in oxygen at these temperatures and times.

The losses in ductility arising from the presence of notches or contamination of the surface can be overcome by etching or electropolishing to remove the affected layer.

Most of the wrought chromium sheet prepared could be bent successfully 180° at room temperature. Sheet in the completely recrystallized condition, however, fractured in a completely brittle manner during attempted bending. The authors were able to prepare recrystallized chromium having some bend ductility at room temperature and learned that the recrystallized material is more sensitive to embrittlement by notches and impurities than the wrought material.

A hypothesis, based on Cottrell locking effects, was proposed to explain these observations. It is postulated that the presence of nitrogen in solid solution in the chromium makes it possible for the Cottrell mechanism to operate, and that chromium in which the dislocations are anchored by nitrogen atoms exhibits similiar behavior to that shown by iron containing carbon and nitrogen at subzero temperatures. If the nitrogen content is reduced below a critical concentration with respect to dislocation density, significant Cottrell locking does not occur and the material is ductile. Also, increasing the temperature provides thermal energy to reduce the effectiveness with which dislocations are anchored by nitrogen atoms, so that a temperature is reached at which dislocation locking is ineffective and the material becomes ductile.

An explanation of the notch-brittleness of chromium is offered. This is based on the action of triaxial stresses at the root of a notch in raising the effective yield stress. Brittle behavior is encountered when the effective yield stress is increased to such a value, through the agency of notches and Cottrell locking, that it exceeds the fracture stress.

D. J. MAYKUTH

Factors Affecting Strength of Brazed Joints*

In any brazing operation the nature of the bond, and hence the strength of the brazed joint, is chiefly determined by the brazing temperature, brazing time, respective composition of the base metal and filler metal, and thickness of the joint. Perhaps the most important relationship is between tensile strength and thickness of the filler metal.

A survey of the literature has revealed a lack of agreement among researchers which appears related to use of commercial alloys in their investigations. Many of these alloys, consisting of from four to seven different metals, form extensive solid solutions and intermetallic compounds with the base metal, thus further increasing the number of factors which may influence the strength of a brazed joint.

These complicating influences were avoided in this investigation. The report describes the determination and analysis of tensile strength-joint thickness curves for low-carbon steel (S.A.E. 1020) bars induction brazed with pure silver, pure copper, silver-copper eutectic alloy (B Ag 8), and the 85% silver, 15% manganese alloy (B Ag Mn). Comparative curves were obtained with 1% carbon steel drill-rod bars brazed with pure silver and pure copper.

A reproducible method of brazing tensile bars by means of high-frequency induction heating was evolved to take advantage of a rapid heating rate, thereby minimizing diffusion of iron into the filler metal.

Despite the precise jigging and reducing atmospheres incorporated into the brazing apparatus, examinations of the fractured specimens revealed that only in comparatively few specimens were the joints absolutely sound and voidless. The highest tensile strength values were produced by joints that were *(a)* voidless and *(b)* broke in tension in the middle of the filler metal disk.

Two principal types of imperfections were investigated. Gas inclusions, which occurred primarily along the plane of symmetry of the

(Continued on p. 212)

*Digest of "Investigation of Factors Determining the Tensile Strength of Brazed Joints", by Nikolajs Bredzs, *Welding Journal*, Vol. 33, November 1954, p. 545s-563s.

Brazed Joints . . .

joint, were attributed to segregation of gases during solidification. Failure of the joint at interface of base and filler metals happened only with the B Ag 8 brazing alloy and was attributed to inadequate reduction of oxide films at the low brazing temperature of this alloy.

Since only absolutely perfect joints and joints with areas of voids not exceeding 10% of the brazed area were selected for the construction of tensile strength-joint thickness curves, these curves are considered to represent the relationships for the ideally prepared joints.

All of the curves showed the same pattern: The tensile strength of the joint increases with the decrease of the filler metal disk thickness, due exclusively or almost exclusively to the increase of biaxial constraint — in other words, on account of the increase of suppression of the neck-down effect of the filler metal disk.

In view of the almost complete suppression of the plastic deformation in extremely thin joints the stress distribution in the filler metal may have approached a state of triaxiality. Under such conditions the fracture strength of pure silver was increased in these experiments from 21,000 to 84,350 psi, at a film thickness of 0.00014 in., and the fracture strength of copper was increased from 32,000 to 106,500 psi. at a film thickness so small as to be microscopically unmeasurable.

The comparative strength of pure silver and pure copper brazed butt joints in mild steel and drill rod demonstrated that the joint strength increased with an increase in the tensile strength of the base metal. Examination of the summary curves indicated that for an equivalent filler metal disk of 0.005 in. this increase could be expected to raise the ultimate from approximately 48,000 to 60,000 psi. for the silver joints and from approximately 49,000 to 81,000 psi. for the copper joints.

Although iron and silver are reported as being insoluble in each other, the silver brazed joints invariably broke in the middle of the silver disk, indicating that formation of an alloy system between the base metal and filler metal is not an essential requisite for making a strong brazed joint. P. Patricia

information memo from the engineering laboratories of CONSOLIDATED VACUUM CORPORATION

CVC

Volume 1 Number 3

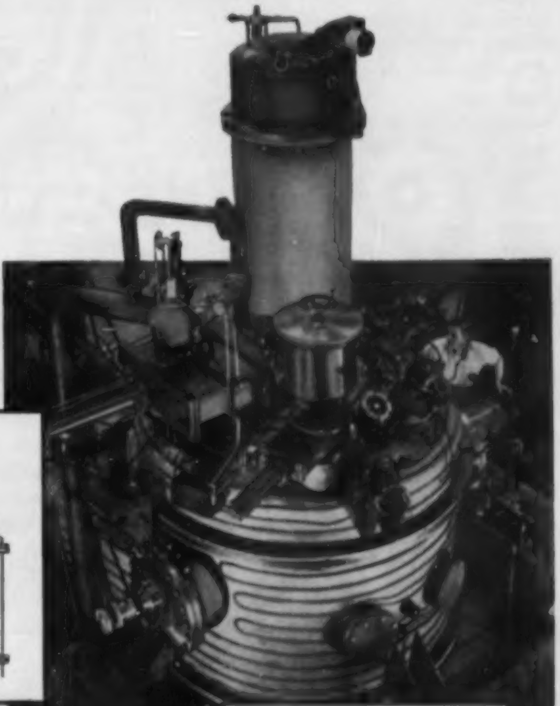
MATERIALS HANDLING IN VACUUM METALLURGY

Remote controls

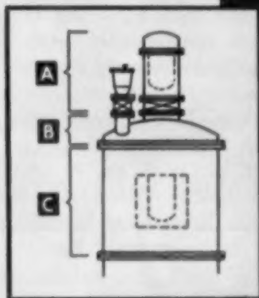
move materials in a semi-continuous, high-vacuum melting and casting furnace.

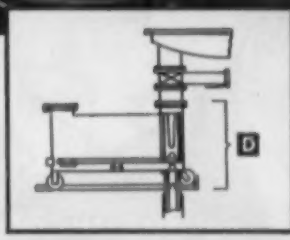
Like his associates who work open-air furnaces, the high-vacuum metallurgist introduces his charge to the crucible, controls it during melt, samples it, adds alloying materials, and pours ingots.

Unlike his open-air associates, he must do all this from *outside a closed chamber, without breaking vacuum.*



The furnace discussed in text being readied for delivery. This is a true semi-continuous, high-vacuum melting and casting furnace with a 1000 pound capacity. It is now installed at the customer's plant.





Schematic drawings of the semi-continuous, high-vacuum furnace.

A Interlocks through which bulk charge and alloy materials are introduced without breaking vacuum.

B Cover with temperature measurement and inspection devices.

C Chamber containing trunion-supported coil-crucible.

D Mold chamber and vacuum interlock. Ram lifts mold to short-path pouring position under crucible lip, then lowers it to indexed table where it moves to hot-topping position.

Bulk charging

How to cope with the packing factor.

Entry to the crucible is made through a charging interlock. The operator loads the interlock with a self-contained windlass. Coils within the interlock preheat the charge, speeding up the production cycle and reducing thermal shock to the crucible.

One packing technique is to incase the charge in a can made of the same charging material. The can initially extends above the crucible. As it melts, the can settles slowly into the crucible producing a full capacity charge.

The alternative method is to make a second bulk charge to supplement the volume lost in melting the initial charge.

Inspection, sampling, alloy additions

How to control the melt and its composition.

A thermocouple on the furnace cover permits the operator to determine the melt temperature at all times. The cover also contains a bridge breaker and inspection devices. A manual sampler quickly provides specimens of the melt. All these devices focus around the operator.

Since it is usually desirable to hold alloying materials until the bulk charge is melted, there is a second interlock for alloy additions. The operator introduces these materials in precise amounts at exactly the right moment to produce the desired composition.

The alloying mechanism normally consists of a number of cans with drop-out bottoms. Each one moves into position on an indexed platform for direct down-the-chute discharge into the crucible.

A Syntron vibrator attachment is also available. This adds the alloy materials into the melt gradually through a vibrating hopper.

Mold pouring

How to achieve a short pour distance.

When pouring multiple molds, a pneumatic ram lifts the individual mold from a rotating table to a position directly under the crucible lip. In this way, the pour distance from the crucible to the mold bottom is at a minimum and better ingot quality results. The absence of spouts and funnels with this technique is an advantage from the standpoint of ingot purity.

Ingot handling

How to avoid piping.

The ram lowers the filled mold to the rotating table. The table moves the mold to a hot-topping position which holds piping at a minimum. At the same time an empty mold is positioned for ram-lifting.

Automatic controls are the rule. The furnace operator guides all his materials by push buttons or turn wheels.

If you are considering a high-vacuum furnace for your plant, allow us the opportunity of discussing the subject with you. Please contact ***Consolidated Vacuum Corporation, Rochester 3, N. Y.*** (a subsidiary of Consolidated Engineering Corporation, Pasadena, California). Reprints of this and others in the *information memo* series are available on request.

Consolidated Vacuum Corporation, ROCHESTER 3, N. Y.

CVC sales now handled through Consolidated Engineering Corporation with offices located in: Albuquerque • Atlanta • Boston • Buffalo • Chicago • Dallas Detroit • New York • Palo Alto • Pasadena • Philadelphia • Seattle • Washington, D. C.

High-Temperature Brazing of Molybdenum*

THE AUTHORS report the results of a study of 16 high-temperature brazing alloys, having melting points above 1800° F. The recrystallization of molybdenum sheet during brazing is accompanied by severe embrittlement of the molybdenum itself. Retort and torch brazing result in such embrittlement; induction brazing in argon was the most satisfactory method from the standpoint of both quality and practicability. Unfortunately, the latter method in actual practice would be limited by the size and shape of the piece being formed.

The article is of value in that it established the relative merit of the high-temperature brazing materials employed. Fluxes are also formulated for oxy-acetylene brazing and observations are made concerning braze wetting characteristics. Three grades of molybdenum sheet were used in the investigation, two of which were processed by powder-metallurgy techniques with the third being made from arc-cast carbon deoxidized ingots. Exposures varying from 30 sec. to 2 min. at 2400° F. were found to reduce the bend ductility to a value of about one-half that of the as-received sheet. A correlation with microstructure revealed that, as amount of recrystallization increased, ductility decreased.

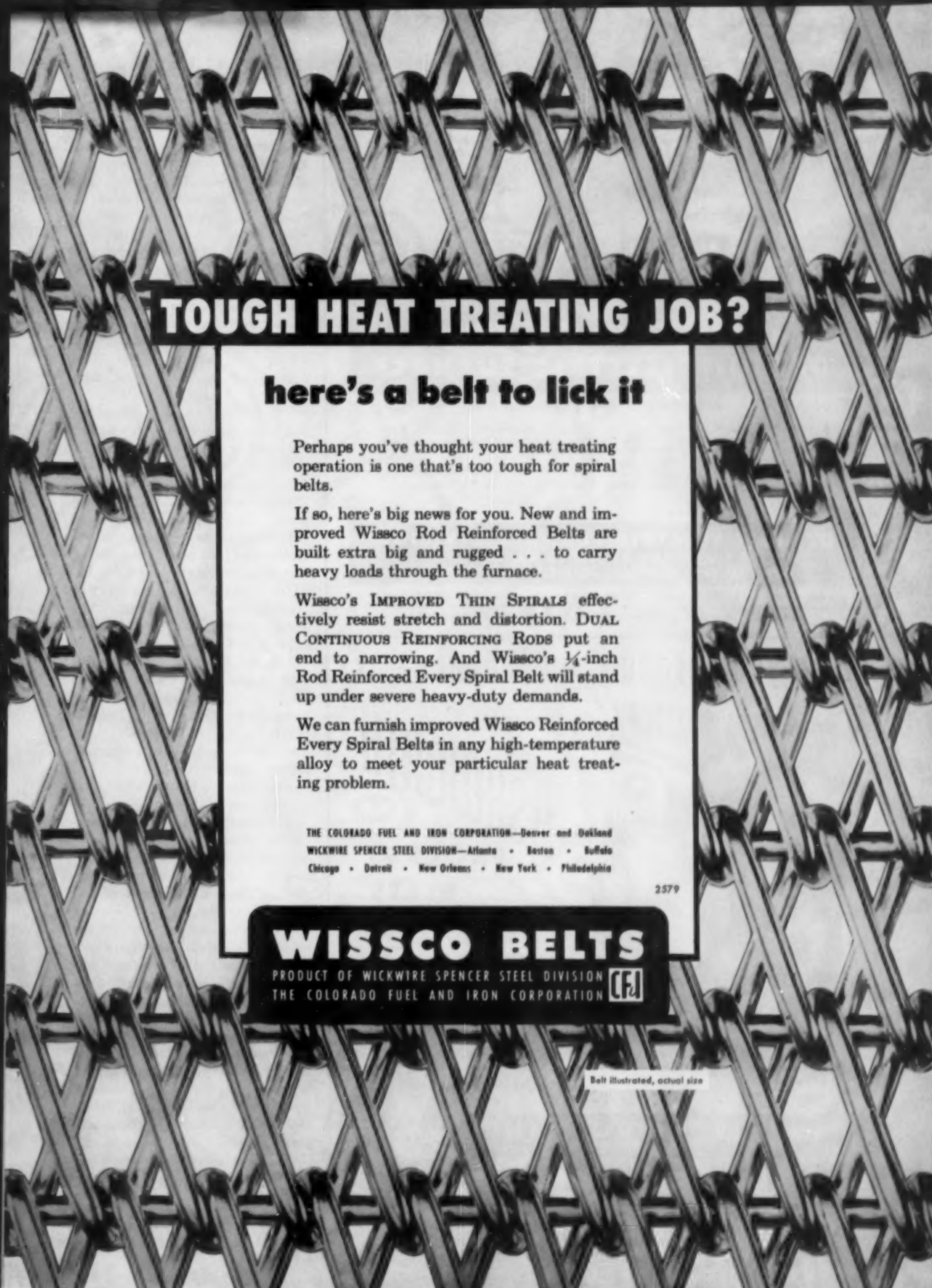
Retort brazing in vacuum was done by etching single and double lap-type joints, filling the overlapping portions with strips of brazing alloy foil, and clamping in jigs. The procedure was accompanied by relatively long heating times, and all joints were subsequently found to fail in a brittle manner when bending stresses were imposed by a dynamometer.

Oxy-acetylene brazing was attempted with the following brazing alloys: 60 Pd, 40 Cu; 60 Pd, 40 Ag; Hastelloy C; Haynes Stellite 21; Haynes Alloy 25; 25-20 stainless; 18-8 stainless; Chromel; Monel; and 70 Cu, 30 Ni. All wet the molybdenum with the exception of the 25-20 and 18-8 stainless steels, when used with a development flux of the following composition: 10% boric acid, 6% AgCl, 10% LiCl, 27% Oxweld Brazo flux, 20% NaF and 27% CaF. This flux is difficult to remove after brazing but it is satisfactory for the preparation of test specimens. Brazing times of 25 to 50 sec. were employed. Subsequent dynamometer tests produced tensile failure in the base metal rather than shear failure in the joint.

In order to obtain very rapid heating cycles, and thereby minimize embrittlement, induction brazing apparatus was constructed. The best results were with a small Vycor tube and induction coil, under which conditions it was possible to melt the brazing alloys in 5 to 6 sec. and to cool the joint to below 1800° F. in 20 sec. A slotted type of tensile

(Continued on p. 216)

*Digest of "Brazing Molybdenum for High-Temperature Service", by M. I. Jacobson and D. C. Martin, *Welding Research Supplement*, Vol. 20, February 1955, p. 65s-74s.


TOUGH HEAT TREATING JOB?
here's a belt to lick it
Perhaps you've thought your heat treating operation is one that's too tough for spiral belts.
If so, here's big news for you. New and improved Wissco Rod Reinforced Belts are built extra big and rugged . . . to carry heavy loads through the furnace.
Wissco's Improved Thin Spirals effectively resist stretch and distortion. Dual Continuous Reinforcing Rods put an end to narrowing. And Wissco's ¼-inch Rod Reinforced Every Spiral Belt will stand up under severe heavy-duty demands.
We can furnish improved Wissco Reinforced Every Spiral Belts in any high-temperature alloy to meet your particular heat treating problem.
THE COLORADO FUEL AND IRON CORPORATION—Denver and Oakland
WICKWIRE SPENCER STEEL DIVISION—Atlanta • Boston • Buffalo
Chicago • Detroit • New Orleans • New York • Philadelphia
2579
WISSCO BELTS
PRODUCT OF WICKWIRE SPENCER STEEL DIVISION
THE COLORADO FUEL AND IRON CORPORATION
CF&I
Belt illustrated, actual size

Brazing Molybdenum . . .

specimen was used with this apparatus. The specimen consisted of two pieces of sheet metal joined at right angles along a slot placed in the end of one of the pieces. This specimen was found to fail in the base metal during tensile testing at room temperature, but true shear failures occurred through the joint at 1800° F. Inconel, Haynes Alloy 25, and Monel were the most promising brazing alloys studied, with respective braze shear strengths at 1800° F. of 18,800, 14,250, and 12,750 psi. Various noble metal brazes gave lower resultant shear values.

The diffusion of molybdenum into the braze metal during the melting operation was confirmed by microstructure, hardness tests, tensile tests, and joint melting tests. This diffusion may either increase or decrease the strength of the joint, depending on composition and intermetallic compound formation. The stress-rupture strength for 100 hr. at 1800° F. of an induction-brazed Inconel joint was found to be approximately 5000 psi., which value is 50% of the wrought molybdenum value at this same temperature. Suggested fields for further study include a determination of creep properties, strength tests at 2000° F., the use of molybdenum-titanium alloys of higher recrystallization temperature, and the development of new brazing alloys and ductility test methods.

REVIEWER'S COMMENT: Embrittlement of molybdenum during brazing and prior to heat-engine utilization is a more serious engineering problem than the authors indicate. Even though subsequent forming operations are not required on the brazed joint, operating components are subject to severe vibration and notch-brittle materials are viewed with alarm. The utilization of molybdenum alloys of higher recrystallization temperature is a promising and logical direction of future effort. It is of interest to note that Ziegler, Meinhart and Goldsmith (*Transactions* A.S.M., Vol. 42, p. 175-198) show that nickel-base materials, such as Inconel, are also good molybdenum cladding materials. The Inconel relationship may be more than coincidence. J. P. DENNY

ACME *Automatics* DELIVER

HIGH OUTPUT AT LOW COST ON PRODUCTION FINISHING

ACME *Semi-Automatics*

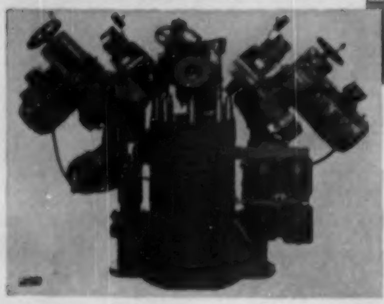
Acme Semi-Automatic Polishing and Buffing Machines are available in a wide range of types and spindle arrangements.

LEFT—Acme Type B-1C, single spindle.

RIGHT—Acme Type L4, four spindle, an automatic indexing machine.

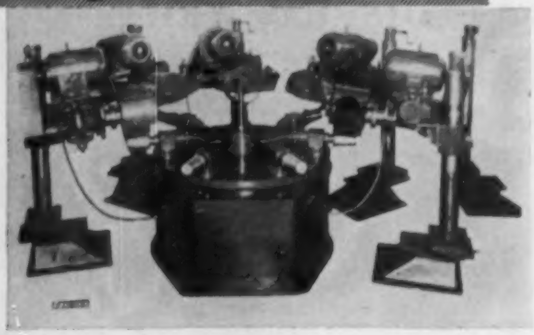
Acme "Semi's" meet production and finish demands on a great variety of parts. Their efficiency and dependability has been fully demonstrated in industry.

CATALOG ON REQUEST



ACME *Rotary Automatics*

Acme Rotary Automatics are furnished with Indexing and Continuous table operation. They are available with table sizes from 18 inches to 24 feet diameter and are outstanding production machines.



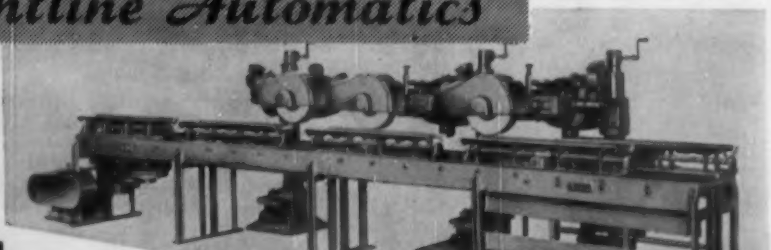
ABOVE—Acme Type L-8-L Rotary with variable speed control with less than one second index interval. Unusually efficient for finishing small parts.

RIGHT—Acme 66 inch, 7 station indexing rotary with right angle attachment illustrating one of many efficient Acme arrangements of these versatile units.

CATALOG ON REQUEST

ACME *Straightline Automatics*

Acme Straightline Automatics standardize polishing and buffing operations at high production levels at low unit costs. Available in horizontal return over and under, loose fixture and other types and from 20 to 80 feet in length. Many effective arrangements to meet specific requirements.



ACME HORIZONTAL RETURN STRAIGHTLINE

This 20 ft. Straight line is shown with three Acme Type G-3 adjustable floating head polishing and buffing lathes. It can be increased in length to 80 ft. by adding standard 10 ft. sections.

CATALOG ON REQUEST

RECOMMENDATIONS AND QUOTATIONS

Please send blue prints or finished and unfinished samples of part to be finished with detailed information on present finishing operation and production requirements. Recommendations and quotations will be furnished.

SPECIAL MACHINERY · AMC · AUTOMATIC BUFFING MACHINES

ACME *Manufacturing Co.*

1400 E. 9 MILE RD., DETROIT 20 (Ferndale) MICH.

Builders OF AUTOMATIC POLISHING AND BUFFING MACHINES FOR NEARLY HALF A CENTURY

TITANIUM STRIP is descaled continuously on time cycles as low as 30 seconds, with excellent results.

10-MINUTE IMMERSION loosens scale on 5 tons of stainless wire. A water quench, 3-minute acid dip, and final water rinse produce a clean, bright surface with no pitting or etching.

Use this fast, safe Hooker Process for descaling steel and titanium

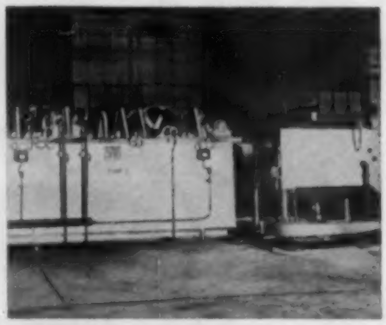
Descale alloy steels and titanium in any form—rapidly, safely—using the Hooker Process with Virgo® Descaling Salt.

A bath of molten Virgo Descaling Salt quickly converts scale, rust, and other surface impurities to an acid-soluble coating. A quench, acid dip, and final spraying then remove this coating in from one-tenth to one-hundredth the usual pickling time, with no measurable effect on the base metal.

You can easily set up the Hooker Process for batch or continuous operation on any form of work including strip, sheets, bars, wire, tubes, plate, castings, forgings, and fabricated parts. You can usually process work as fast as your handling methods allow, with a minimum of supervision. Operation is safe for personnel, and there is little or no spent-acid disposal problem.

You can profit by the experience of more than 50 companies now using the Hooker Process successfully to speed up descaling of alloy steels and titanium in practically every form.

You'll get quick service on any descaling problem, by writing or phoning us. Complete test and engineering facilities are at your disposal, without obligation.



LIGHT-GAUGE ALLOY STRIP is descaled at 20-35 ft. per min. in this Virgo bath, after annealing.

Send for these bulletins—Get the whole story on Virgo Descaling Salt for alloy steels and titanium . . . how the Hooker Process works, its advantages, how to set up a Virgo descaling line, and the services you enjoy as a user. No obligation. Write us today.

1905—Half a Century of Chemicals
From the Salt of the Earth—1955

HOOKER CHEMICALS

HOOKER ELECTROCHEMICAL COMPANY

30 Forty-seventh St., Niagara Falls, N. Y.

NIAGARA FALLS • TACOMA • MONTAGUE, MICH. • NEW YORK • CHICAGO • LOS ANGELES

Metals Engineering

As described by Mr. Harry L. Ingram, Jr.,
***Manager*, Technical Development Division**

"Designing for safety" is the subject under discussion here between these Metals Engineers. What metals and alloys should be employed in manufacturing this product to insure safe operation? How should they be fabricated, heat treated, finished? To their knowledge of the technology of the process involved, each man adds his expertness in metals.

The buying influence of these men is obvious —starts right at the point where specifications are written.

In selling a process to steel mills and foundries, our Metals Engineers have to know metals,

Powder Metallurgy in Atomic Energy

ASM CONVENTION—PHILADELPHIA, OCTOBER 17-21, 1955

Jointly sponsored by U.S. Atomic Energy Commission and American Society for Metals

General Chairman:
HENRY H. HAUSNER,
Manager of Atomic Energy Engineering
Sylvania Electric Products, Inc.

1. **"General Metallurgical Problems in the Design of Nuclear Power Reactors"**
   Vincent P. Calkins
   Aircraft Nuclear Propulsion Project
   General Electric Co.

2. **"Preparation of Metal Powders for Nuclear Reactor Purposes"**
   Premo Chiotti and Harley A. Wilhelm
   Institute for Atomic Research
   Iowa State College

3. **"The Latest Developments in the Theory of Sintering"**
   Leslie L. Seigle, Head
   Fundamental Metallurgy Section
   Sylvania Electric Products, Inc.

4. **"The Powder Metallurgy of Beryllium and Zirconium"**
   Harold Hirsch
   Knolls Atomic Power Laboratory
   General Electric Co.

5. **"Alloy Formation by Powder Metallurgy"**
   Henry A. Saller and Frank A. Rough
   Battelle Memorial Institute

6. **"New Methods of Powder Metallurgy for Nuclear Reactor Purposes"**
   William D. Manly
   Oak Ridge National Laboratory

7. **"Safe Handling of Pyrophoric and Radioactive Materials"**
   L. R. Kelman, A.B. Shuck and R. C. Goertz
   Argonne National Laboratory

this meeting one of the many big features at the . . .

NATIONAL METAL CONGRESS & EXPOSITION—PHILADELPHIA

New

CODE OF ETHICS SEAL

. . . assurance of sound engineering for industrial gas equipment

When you see this new *"Code of Ethics"* Seal displayed on industrial gas equipment, it's your assurance that sound engineering and proved research underlie design and construction of each component part. This is part of the Code through which manufacturers pledge that highest standards of safety, performance and durability are being met. Watch for this *Seal* . . . symbol of integrity and quality . . . when you buy industrial gas equipment.

INDUSTRIAL GAS EQUIPMENT DIVISION

G. A. M. A.

Space for this ad donated by:

AMERICAN GAS FURNACE CO.

ELIZABETH, NEW JERSEY

Member and Signer of *"Code of Ethics"*

BURNERS · FURNACES · AUTOMATIC EQUIPMENT FOR ANNEALING BRAZING · HEAT TREATMENT OF METALS

SEND COUPON for complimentary copy new booklet *"Code of Ethics"*

Industrial Gas Equipment Division, G.A.M.A.
60 East 42nd Street, New York 17, N. Y.

Gentlemen: Please send me a free copy of your "Code of Ethics" and list of signers.

Name ______________________

Company Name ______________________

Address ______________________

City ______________ State ______________

This is Spectrograph Performance that speaks for itself:

DISPERSION

— up to 0.17 A/mm

RESOLUTION

— over 300,000

JAco *Ebert*

SPECTROGRAPH

with Order Sorter

This is truly "Tomorrow's spectrograph here today" . . . an instrument so ingeniously designed it adds new dimensions to your research . . . provides fast reliable answers to your production control problems.

The instrument consists of a *plane grating* spectrograph (with original 15,000 line/inch certified grating) that produces outstanding dispersion, resolution and upper wavelength coverage, and an *Order Sorter* that presents several orders simultaneously at high dispersion, each as an individual spectrum. They combine to produce an instrument that provides an extremely versatile choice of dispersions — from low to ultra high — while still providing broad wavelength coverage and reasonable speed.

Whatever your quantitative or qualitative analysis problems, the JAco Ebert Spectrograph with Order Sorter offers you important *exclusive* advantages. For more complete information, write today for new 8-page catalog.

Offers all these important advantages

Flexibility — Normal dispersion for routine work . . . ultra-high dispersion and resolution to check on line interferences, line shapes or self-reversal or for isotope work . . . intermediate dispersions suitable for routine analysis of materials with complex spectra.

Compactness — Positioning of source unit and controls reduce space requirements to minimum.

Stigmatism — Hartmann diaphragm and fishtail, stepped sector disc, stepped filters and other intensity control devices may be used directly at slit.

Speed — Practical speed matches famous Wadsworth grating instruments.

Ease of Operation — Push button operation, thoughtfully grouped controls and a minimum of critical adjustments speed your work.

Unmatched High Dispersion Performance — Provides higher dispersion and resolution than any other spectrograph . . . covers the whole analytically useful wavelength range in a single exposure.

Versatility — The basic spectrograph can be fitted with both integrating and scanning type direct reading attachments.

JAco **JARRELL-ASH COMPANY**

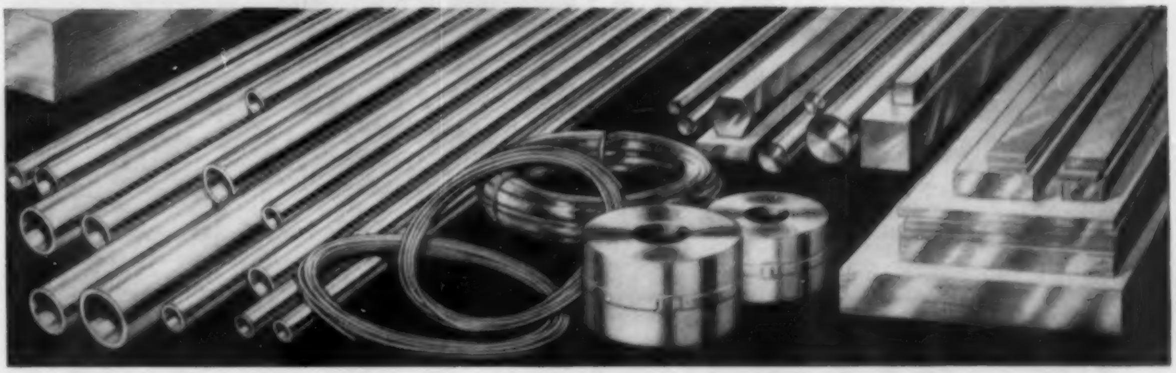
26 Farwell Street, Newtonville, Mass.

Sales Offices: Detroit 13580 Capitol Ave. · El Cerrito, Calif. 1344 Devonshire Dr. · Pittsburg, Pa. 916 Greenhill Rd. · Los Angeles (Duarte) [illegible] Rd.

CHASE® IS THE PLACE

Illustrated above: **Just three of the 25 efficient Chase warehouses dotting the nation.**

FOR STAINLESS STEEL!



Chase®

BRASS & COPPER CO.

WATERBURY 20, CONNECTICUT • SUBSIDIARY OF KENNECOTT COPPER CORPORATION

CALL THE CHASE WAREHOUSE NEAR YOU!

The Nation's Headquarters for Brass & Copper

Albany†	Chicago	Detroit	Los Angeles	New York	St. Louis
Atlanta	Cincinnati	Grand Rapids†	Milwaukee	Philadelphia	San Francisco
Baltimore	Cleveland	Houston	Minneapolis	Pittsburgh	Seattle
Boston	Dallas	Indianapolis	Newark	Providence	Waterbury
Charlotte†	Denver	Kansas City, Mo.	New Orleans	Rochester†	(†sales office only)

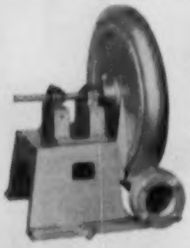
Burning Issues

Eclipse

Published by Eclipse Fuel Engineering Company
Rockford, Illinois

Eclipse Blowers deliver air at constant pressure . . . regardless of load!

Connect several burners or furnaces to the blower . . . vary the air capacity in each . . . and the air pressure to *all* remains constant! For, Eclipse Centrifugal Pressure Blowers are recognized for their constant, straight-line delivery pressure curves, operating at partial or full loads. Heavy and durable . . . with individually balanced rotors . . . they give you smooth operation at high speeds and dependable, nonpulsating air supply for efficient combustion with gas or oil fuels. For pressures as low as 2 oz. or as high as 2 lbs., there's an Eclipse Centrifugal Pressure Blower for every job!

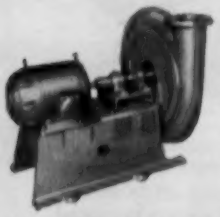


TYPE "P"—PULLEY DRIVE

For operation off a pulley, line shaft, or separate power source, the Type "P" is equipped with special rotor shaft, precision shaft bearings, and pillow blocks—but not pulley. Pulley and drive should be capable of operating rotor shaft at 3450 rpm.

TYPE "S"—SINGLE INLET

For use as an exhauster or for applications in which air intake is from an outside source or through an air filter, the Type "S" has motor side closed off by a close-tolerance plate and felt bushing around motor shaft. Inlet may be threaded or flanged for pipe connection, or air filter. Type "S" construction available for all types of Eclipse Blowers.

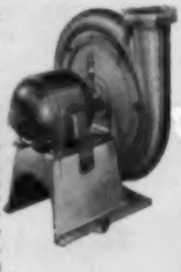


TYPE "D"—DOUBLE BEARING

Provides rigid, precisely aligned bearing support independent of motor bearings because rotor is mounted on special shaft supported by outside auxiliary bearings. The 3600 rpm motor is connected to shaft by a flexible coupling. Special extended base provides maximum rigidity and support. Design permits use of standard length motor shaft in Gas Boosters.

ECLIPSE GAS BOOSTERS ELIMINATE NEED FOR COOLING EQUIPMENT AND BY-PASS REGULATORS

Centrifugal design eliminates need for cooling equipment in by-pass regulators required by positive-displacement boosters. Eclipse Boosters may be operated at partial or full loads, maintaining constant delivery pressure. They're gas-tight and spark-proof . . . designed for continuous trouble-free operation. Use them as a pressure booster on undersized gas lines, or as an air-gas pressure mixer for premix or standby applications. Write for Bulletins K-100 and K-200.



Eclipse Fuel Engineering Co., 1127 Buchanan St., Rockford, Ill.
Eclipse Fuel Engineering Co. of Canada, Ltd., Toronto, Ont.

KENTRALL Hardness Tester

MAKES BOTH Superficial & Regular Tests

Thoroughly proven in the field over the past two years, the KENTRALL makes all Superficial Rockwell tests (15, 30 and 45 kg. loads), as well as all Regular Rockwell tests (60, 100 and 150 kg. loads).

Want complete information? Write for Bulletin RS.

The **Torsion Balance** *Company*

Main Office and Factory: Clifton, New Jersey
Sales Offices: Chicago, San Francisco

REMOVES Water Film IMMEDIATELY

AHCO

WATER *Displacing* COMPOUND

Produces an unspotted, dry surface. The work can be lacquered immediately without waiting for solvent to dry. For full details write for bulletin B-1.

Over a Century of Service

APOTHECARIES HALL CO.

1 BENEDICT STREET · WATERBURY · CONN

Metal Progress

Taylor Lyman, *Publisher*

A. P. Ford, *Sales Manager*

George H. Loughner, *Production Manager*
7301 Euclid Ave., Cleveland 3—UTah 1-0200

District Managers

John B. Verrier, Jr. and James P. Hontas
55 W. 42nd St., New York 36—CHickering 4-2713

Ralph H. Cronwell
53 West Jackson Blvd., Chicago 4, Ill.—WAbash 2-7822

Don J. Billings
7301 Euclid Ave., Cleveland 3—UTah 1-0200

PUBLISHED BY AMERICAN SOCIETY FOR METALS, 7301 EUCLID AVE., CLEVELAND 3, OHIO—W. H. EISENMAN, SECRETARY

• Index to Advertisers •